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COMPLETION REPORT FOR THE GEOCHEMICAL CHARACTERIZATION PERFORMED IN SUPPORT OF THE QROU FIELD STUDIES

WELDON SPRING SITE REMEDIAL ACTION PROJECT
WELDON SPRING, MISSOURI

AUGUST 2002 **REV. 0**

ECORD

U.S. Department of Energy
Oak Ridge Operations Office
Weldon Spring Site Remedial Action Project

Prepared by MK-Ferguson Company and Jacobs Engineering Group

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PLAN TITLE: Completion Report for the Geochemical Characterization Performed in Support of the QROU Field Studies	

APPROVALS

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DOE/OR/21548-919

Weldon Spring Site Remedial Action Project

Completion Report for the Geochemical Characterization Performed in Support of the QROU Field Studies

Revision 0

August 2002

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Prepared for

U.S. DEPARTMENT OF ENERGY
Oak Ridge Operations office
Under Contract DE-AC05-86OR21548

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8-23-02

ABSTRACT

The selected remedy in the *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site* (Ref. 1) requires that two field studies be performed to support the decision for long-term monitoring of groundwater as the remedial alternative. These field studies consist of (1) installing and operating an interceptor trench and (2) hydrogeologic and geochemical sampling in the area of uranium impact. These studies are being performed to verify the effectiveness of uranium removal by groundwater extraction methods and to provide additional data to support the contaminant fate and transport models for the quarry area.

This report presents the geochemical data gathered during the recent field program, as well as an analysis of the data. The purpose of this study was to gain a better understanding of the impact of the natural environment in the alluvial material north of the slough on the fate of uranium contamination in the shallow aquifer.

The results of the geochemical characterization have provided a better understanding of the natural geochemistry of the alluvial aquifer north of the Femme Osage slough and its impact on the on the fate of uranium contamination in groundwater. This area contains a naturally occurring oxidation/reduction front, which acts as a barrier to the migration of dissolved uranium by inducing its precipitation. The physical and chemical parameters measured in groundwater samples were successfully correlated with the physical properties of the aquifer material, which support observations and interpretations made during previous investigations, and the conceptual fate and transport model presented in the *Remedial Investigation* (Ref. 9).

This study confirms that the primary mechanisms controlling the distribution of uranium in groundwater in the quarry area are precipitation due to the presence of an oxidation-reduction front and the sorption in the aquifer materials north of the slough. The distribution of dissolved uranium in groundwater reflects an environment where the chemically reducing portion of the alluvial aquifer exerts an immediate effect on the distribution by rapidly causing uranium to precipitate out of solution over a very short distance. The rapid change in uranium soil concentrations at the oxidation/reduction contact supports the dramatic decrease in uranium groundwater concentrations within a distance of less than 100 ft.

The attenuation mechanisms at work in the area north of the slough are reduction and adsorption. The capacity of the reduction zone should not be limited. As long as reducing conditions persist, dissolved uranium should precipitate out of solution. The sorption of uranium onto the aquifer materials does have a limited capacity. As uranium is sorbed, sites on the aquifer material will be used up until it has reached capacity. Since both of these mechanisms are at work and reduction of uranium into insoluble forms is the predominant attenuation mechanism, the attenuation of uranium in this area should be unlimited.

The reducing environment associated with the Femme Osage slough is the result of natural hydrological and biological processes that have been operating since the end of the last ice age, or at least 10,000 years. During that time, the Femme Osage stream channel likely meandered across the Missouri River flood plain. The slough can be considered a permanent hydrologic feature with the diversion of Little Femme Osage and Femme Osage Creeks and the installation of the control gate at the confluence of the slough and the Missouri River. The Missouri River has flooded in recent times and inundated the slough; however, the location of the slough has not changed. The receding floodwater deposits abundant organic material in the slough area that is beneficial as it supplies additional oxidizable material. As long as some portion of the reduced zone in the shallow alluvial aquifer remains saturated, it can be assumed that the reducing conditions will persist.

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1. INTRODUCTION

The selected remedy in the *Record of Decision for Remedial Action for the Quarry Residuals Operable Unit at the Weldon Spring Site* (Ref. 1) requires that two field studies be performed to support the decision for long-term monitoring of groundwater as the remedial alternative. These field studies consist of (1) installing and operating an interceptor trench and (2) hydrogeologic and geochemical sampling in the area of uranium impact. These studies were performed to verify the effectiveness of uranium removal by groundwater extraction methods and to provide additional data to support the contaminant fate and transport models for the quarry area. The interceptor trench was installed and operation of the system is complete. Hydrogeologic field studies were completed earlier in the area of impact and are summarized in the *Completion Report for the Hydrogeological Field Studies in Support of the Quarry Residuals Operable Unit* (Ref. 2). This completion report summarizes the geochemical characterization field studies performed in October and November 2001.

1.1 Purpose and Objectives

The purpose of this report is to present geochemical data gathered during the recent field program, as well as an analysis of the data, to provide a better understanding of the impact of the natural environment in the alluvial material north of the slough on the fate of uranium contamination in the shallow aquifer. The objectives of the geochemical characterization, as outlined in the *Geochemical Characterization Sampling Plan in Support of the QROU Field Studies (Sampling Plan)* (Ref. 3), are to:

- Evaluate the groundwater geochemistry north of the Femme Osage Slough, emphasizing factors that influence the attenuation of uranium in groundwater.
- Estimate the uranium distribution coefficients (K_ds) for the alluvial and bedrock aquifer materials north of the slough.
- Characterize the oxidation state of groundwater throughout the alluvial aquifer and define the boundary of the reducing zone north of the slough.
- Determine the distribution of precipitated uranium across the reducing front.

1.2 Deviations from the Sampling Plan

Borehole QRSB-78 was deleted from the program because of the lack of level terrain at the planned drill site. In addition, the boreholes in this line were closely spaced, which allowed the boring and temporary well to be removed without adversely impacting the characterization. Borehole QRSB-79 was subsequently moved north approximately halfway between its original location and the planned location of QRSB-78.

Some locations that were designated for the collection of distribution coefficient (K_d) samples did not exhibit a saturated oxidized zone; therefore, depth-discrete water samples could not be obtained to determine the K_d for these particular locations. Because of this, two boreholes, QRSB-77 and QRSB-80, were added as K_d sample locations. One of the planned locations, QRSB-65, was initially sampled for K_d determination but was rejected for the K_d calculation because it exhibited an anomalously low uranium concentration in groundwater that was determined to be unrepresentative of groundwater impact at that location.

The method for obtaining soil samples and installing temporary monitoring wells was changed from primarily a push-probe method to an auger method (Section 2.1). The reason for this change was to obtain better sample recovery for both soil and groundwater.

Total dissolved solids (TDS) was deleted from the list of analytes because it was determined not to be critical to the geochemical characterization. The holding time requirement would have had a negative impact on the field program as well.

2. FIELD ACTIVITIES

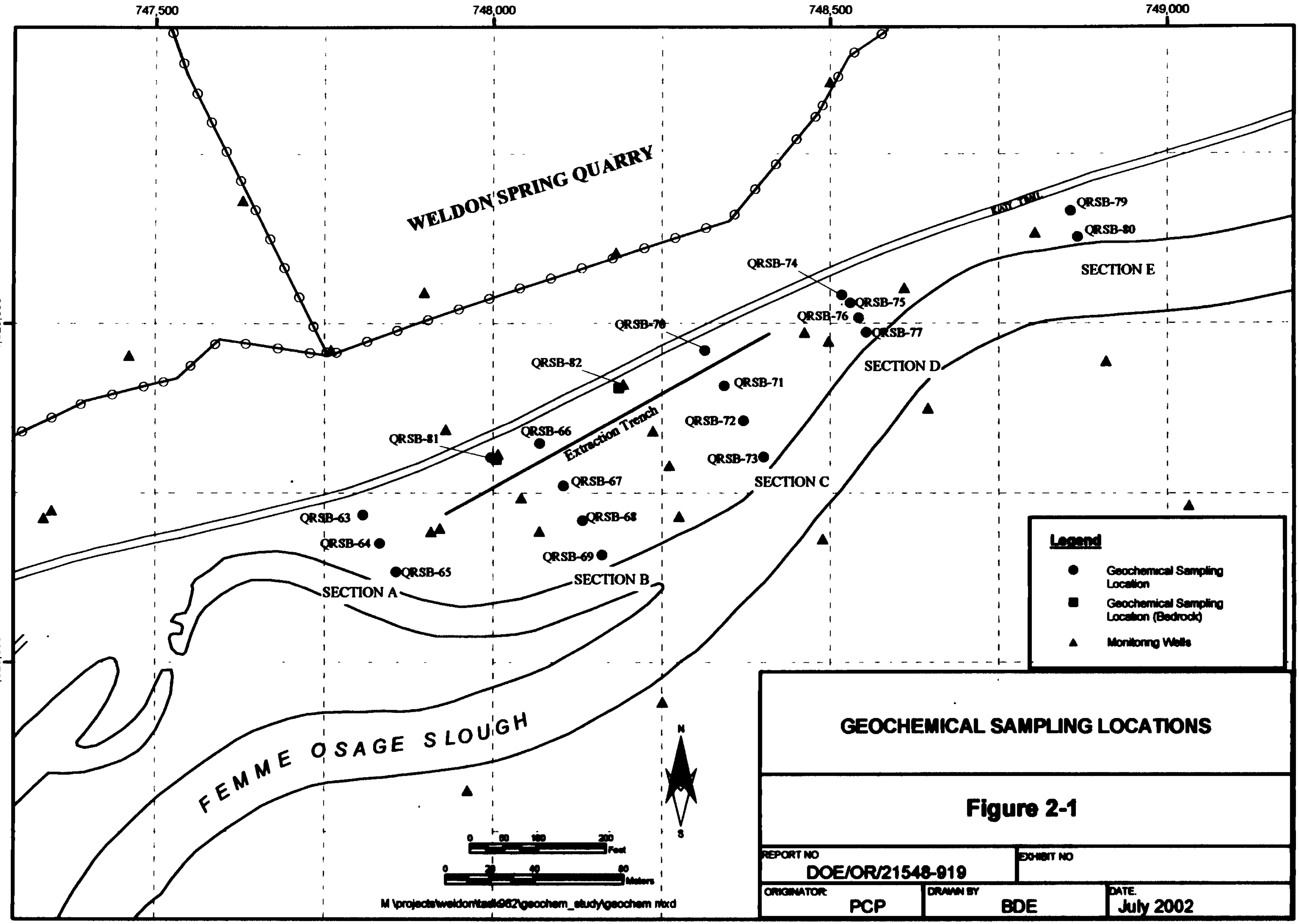
Field studies were conducted in the area immediately south of the quarry and north of the Femme Osage slough from October 25 through November 21, 2001. Geotechnology, Inc., under Work Package 533, Task 13, performed drilling, sampling, and temporary well installations. During that period, drilling and soil sampling were conducted at 17 borehole locations (Figure 2-1), and 21 temporary wells were installed, tested, sampled, and abandoned.

All drilling locations were initially surveyed and staked. After reviewing the staked locations in the field, some locations were moved to accommodate the drilling rig. Location QRSB-78 was deleted because of poor access and close spacing of the borings in the area. Because of the depth-discrete nature of the sampling, up to three borings were drilled at each location to obtain the required soil and groundwater samples.

2.1 Drilling and Sampling Methods

The *Sampling Plan* (Ref. 3) called for continuous sampling using a vehicle-mounted, hydraulically powered, soil probing machine, Geoprobe® or equivalent. Samples were to be collected by pushing a 1-1/2-in diameter by 4-ft long sampler containing transparent plastic (PETG) liners. Two problems with this method became apparent when fieldwork began. The first was sloughing or caving of the hole when the soil sampler was withdrawn to retrieve the sample. When the sampler was withdrawn, the hole commonly would partially collapse, largely due to the suction created by the removal action. This sloughing was most pronounced when sampling progressed to the zone of saturation or where more granular material was encountered. When the next sampler was placed into the hole, the slough would enter the sample tube as it was advanced to the desired sample interval, potentially compromising the sample by cross-contamination from the slough. The sloughing also caused the sample tube to fill before the entire interval was sampled, thereby rejecting some of the desired material by pushing it to the side of the hole.

The second problem was from soil packing off in the sampler before it was full, preventing the remainder of the desired sample from entering the tube. Both the small diameter of the sampler and the more granular nature of the soil contributed to this problem. Again, because the sampler opening was packed off, the desired material was pushed to the side as the sampler was advanced that resulted in poor sample recovery.



747,500
748,000
748,500
749,000
1,028,500
1,028,000
WELDON SPRING QUARRY
FEMME OSAGE SLOUGH
Extraction Trench
SECTION A
SECTION B
SECTION C
SECTION D
SECTION E
QRSB-63
QRSB-64
QRSB-65
QRSB-66
QRSB-67
QRSB-68
QRSB-69
QRSB-70
QRSB-71
QRSB-72
QRSB-73
QRSB-74
QRSB-75
QRSB-76
QRSB-77
QRSB-79
QRSB-80
QRSB-81
QRSB-82
Legend
Geochemical Sampling Location
Geochemical Sampling Location (Bedrock)
Monitoring Wells
N
S
Feet
Meters
M \projects\weldon\task962\geochem_study\geochem.mxd
GEOCHEMICAL SAMPLING LOCATIONS
Figure 2-1
REPORT NO
DOE/OR/21548-919
EXHIBIT NO
ORIGINATOR
PCP
DRAWN BY
BDE
DATE
July 2002

Because of these problems, a CME continuous sampler was used after the first few holes instead of using the Geoprobe® -type system. All of the boreholes were drilled and sampled using an all-terrain CME-550 drill rig equipped with hollow-stem augers with an inside diameter (ID) of 4-1/4 in and outside diameter (OD) of 7-1/4 in. Soil cores were collected using a 3-in diameter, 5-ft long split-barrel tube. The tube was placed just ahead of the auger head to obtain a soil sample that was semi-disturbed. To gather undisturbed samples for bulk density testing, a separate hole was drilled adjacent to the primary soil boring, and a shelby tube was pushed to a depth interval similar to the sample collected for chemical analysis.

The boreholes were drilled and sampled at the locations summarized in Table 2-1 and shown on Figure 2-1. As discussed, some of these locations were moved from the location specified in the *Sampling Plan* (Ref. 3).

Table 2-1 Borehole Summary Table

BOREHOLE ID	SOIL SAMPLE ID	NORTHING	EASTING	GROUND ELEVATION	TOTAL DEPTH (ft) [1]
QRSB-63 [2]	SO-100001	1028216	747807	459.8	11.8
QRSB-64	SO-100002	1028176	747832	458.9	17.5
QRSB-65	SO-100003	1028134	747856	457.7	26.5
QRSB-66	SO-100004	1028324	748069	459.0	11.5
QRSB-67	SO-100005	1028261	748105	458.0	22.5
QRSB-68	SO-100006	1028210	748132	456.1	18.0
QRSB-69	SO-100007	1028159	748161	455.1	17.5
QRSB-70	SO-100008	1028460	748313	462.9	11.2
QRSB-71	SO-100009	1028408	748342	455.2	17.5
QRSB-72	SO-100010	1028356	748371	455.0	18.0
QRSB-73	SO-100011	1028302	748401	455.0	18.0
QRSB-74	SO-100012	1028543	748518	457.8	12.0
QRSB-75	SO-100013	1028530	748529	456.7	12.5
QRSB-76	SO-100014	1028507	748541	454.8	13.8
QRSB-77	SO-100015	1028488	748554	453.5	13.0
QRSB-79	SO-100017	1028671	748854	456.6	11.4
QRSB-80	SO-100018	1028628	748866	457.5	15.0
QRSB-81	SO-100019	1028300	748005	464.4	26.0
QRSB-82	SO-100020	1028405	748186	463.2	24.8

1 Total depth of deepest borehole drilled at that location
2 Location and elevation are approximate

2.2 Soil and Rock Core Sampling

Soil sampling was performed continuously throughout each borehole. Typically, soil from the first boring at a given location was sampled using the CME sampler. Soils cores were retrieved from the sampler, placed on plastic sheeting at the drill site, and described according to procedure ES&H 4.4.7, *Soil, Rock Core, and Rock Chip Borehole Logging*, using the Unified Soil Classification System (USCS). Borehole logs are provided in Appendix A. The field geologist selected samples of recovered soils for chemical analysis based on their depth and physical characteristics, indicating the sample's proximity to the oxidized/reduced zone contact.

Samples were collected at locations selected for distribution coefficient (K_d) determination, as described in the *Sampling Plan* (Ref. 3). Effort was made to obtain these soil samples within the saturated portion of the oxidized zone, but because of the lower water table at the time of sampling, many of the oxidized samples were taken in unsaturated materials. Soil samples for chemical analysis were also collected in the reduced portion of the alluvium at each boring if reducing conditions were evident. These samples provided a comparison of analytes with the oxidized zone samples.

Representative soil samples for chemical analysis were removed from the soil core by first scraping the surficial soil from the core, then cutting a section from the center of the core along the entire interval to be sampled. This section was placed in a stainless steel bowl, thoroughly mixed and homogenized, and placed in an appropriate jar. The jar was labeled with a unique sample number, as described in the *Sampling Plan* (Ref. 3), and placed in a cooler at 4° C. At the end of the workday, the cooler was transported to the main site where the samples were prepared for shipment to the laboratory.

Geotechnical samples were collected at the K_d sample locations to determine grain-size distribution and bulk density of alluvial sediments. At these locations, a shelby tube was pushed to approximately the same depth interval as the chemical analysis sample. The tube was then withdrawn, capped, sealed, labeled, and transported the same day to Geotechnology Inc.'s testing laboratory. The geotechnical test results provided the bulk density for the soil, which was used to calculate the sorbed uranium mass and the grain size (percent clay) for correlation with the K_d value.

The last of the fieldwork involved core drilling the two bedrock boreholes (QRSB-81 and QRSB-82). Following retrieval of the rock from the core barrel, it was described by the field geologist according to procedure ES&H 4.4.7 and temporarily placed in a core box. Once the desired section was cored, the entire interval of cored rock was placed in sealable plastic bags, double-bagged, and transported to the main site for shipment to the laboratory.

2.3 Temporary Well Installation and Groundwater Sampling

Temporary wells were installed at most of the locations to obtain depth-discrete groundwater samples from the alluvium. Placement of the well screens depended on the depth of the oxidized/reduced zone contact evident in soil samples. If the initial soil boring showed that no contact was observed at that location (i.e., the entire soil section was oxidized), then a 2-in temporary well was installed in the initial soil boring. This allowed for a larger surface area in the well from which to draw groundwater. A 5-ft screen was usually placed in these wells, and they were designated as an oxidized or "shallow" well, by placing an "S" after the well number. If a soil boring exhibited an oxidized/reduced zone contact but the water table was below the contact, the borehole was completed in a similar manner by installing a 2-in screen and riser, ensuring that the screen was exclusively within the reduced zone. Typically, a 5-ft screen was placed in these holes, but the well was designated a "reduced" or "deep" well by placing a "D" after the well number.

Where a borehole exhibited a oxidized/reduced zone contact below the water table, the original soil boring was typically not used for well installation. Instead, a second hole was located adjacent to the first and auger-drilled immediately above the contact, and a 2-in polyvinyl chloride (PVC) screen and riser were installed to sample the upper oxidized water in the open hole. Following this, a second well was installed adjacent to the first using a 2-in push-probe casing with an expendable tip. The push probe was hydraulically advanced to the desired depth below the contact and within the reduced zone. A ¾-in screen and riser were then placed inside the 2-in steel casing, and the casing was retracted leaving the expendable tip and exposing the PVC screen to the formation. The 2-in casing was then retracted to a point that would expose the screen to the desired interval for collecting a reduced zone ground-water sample.

Table 2-2 below summarizes the construction of the temporary wells. Wells were not completed with a sandpack, seal, or annulus grout. The only well seal was placed near the ground surface in the form of a shale trap that was placed over the riser pipe and secured approximately 1 ft below ground surface. Plastic sheeting was placed on top of the shale trap to further seal the hole and prevent anything from entering the hole from the top. Completion diagrams for the temporary wells are provided in Appendix A.

Table 2-2 Temporary Well Installation Summary

Well ID	Ground Elevation (ft MSL)	Screened Interval (ft)[1]	Water Level (ft)[1]	Oxidized/ Reduced Contact (ft)[1]	Well Diameter
QRSB-63S	459.8	6.7 – 11.7	9.6	All oxidizing	2 in
QRSB-64S	458.9	9 – 14	10.7	14.9	1 in
QRSB-64D	458.9	15.5 – 17	12.4		¾ in
QRSB-65S	457.7	7.8 – 12.8	9.8	13.4	2 in
QRSB-65D	457.7	19 – 24	14.2		¾ in
QRSB-66S	459.0	6.3 – 11.3	dry	All oxidizing	2 in
QRSB-67S	458.0	7.6 – 12.6	dry	12.7	2 in
QRSB-67D	458.0	14.5 – 17.5	14.5		¾ in
QRSB-68D	456.1	12.7 – 17.7	13.1	9.3	2 in
QRSB-69D	455.1	12.2 – 17.2	10.4	7.5	2 in
QRSB-71D	455.2	12.2 – 17.2	10.7	10.4[2]	2 in
QRSB-72D	455.0	12.6 – 17.6	12.1	10.0	2 in
QRSB-73D	455.0	12.6 – 17.6	12.8	10.0	2 in
QRSB-74S	457.8	6.8 – 11.8	10.7	All oxidizing	2 in
QRSB-75S	456.7	7.1 – 12.1	9.7	All oxidizing	2 in
QRSB-76D	454.8	8.5 – 13.4	8.5	7.5[2]	2 in
QRSB-77S	453.5	1.6 – 6.6	5.5	7.5[2]	2 in
QRSB-77D	453.5	7.6 – 12.6	7.6		2 in

Table 2-2 Temporary Well Installation Summary (Continued)

Well ID	Ground Elevation (ft MSL)	Screened Interval (ft)[1]	Water Level (ft)[1]	Oxidized/ Reduced Contact (ft)[1]	Well Diameter
QRSB-79S	456.6	6.2 – 11.2	9.3	All oxidizing	2 in
QRSB-80S	457.5	6.3 – 11.3	10.2	12.8	2 in
QRSB-80D	457.5	13.0 – 14.5	9.6		¾ in

1 Depth below ground surface
2 Depth to oxidized/reduced zone contact is approximate because of poor sample recovery within contact zone.

Some wells were initially dry, either because of the lower water table or a very tight aquifer matrix. These wells required a significant time (days) to recharge. Two wells (QRSB-66S and 67S) never had inflow because of the lower water table, even after monitoring for a month. A variance was obtained from the Missouri Department of Natural Resources (MDNR) to extend the time for which these two temporary wells would be left in place to allow water inflow.

The temporary wells were sampled using a peristaltic pump. An effort was made to purge each well before sampling to remove the bulk of the turbidity. Wells screened in more granular material (sands) exhibited better permeability and were purged more successfully (i.e. reduced turbidity) than those completed in clays. Once the purging was completed, a .45-micron in-line filter was attached to the discharge line to remove any remaining sediments or colloids. A few of the samples were not filtered because the filter restricted the ability to pump water in very tight (low flow) conditions.

Once the well was purged, sampling commenced in accordance with the *Sampling Plan* (Ref. 3) and procedure ES&H 4.4.1, *Groundwater Sampling*. Typically, the first samples collected were for on-site analysis of redox parameters (Fe^{2+} and S^{2-}) and field parameters (pH, Eh, conductivity, dissolved oxygen, and temperature). Following the on-site testing, samples were collected for laboratory chemical analysis and placed in coolers. At the end of the day, all water samples were transported to the main site for shipment to the laboratory.

2.4 Equipment Decontamination

At the beginning of the fieldwork, a temporary decontamination pad was constructed in a centralized location relative to the borings. All augers and samplers were decontaminated between boreholes by high-pressure washing and air-drying. In addition, the CME inner split-barrels were either pressure-washed or washed in an Alconox® solution and double-rinsed (tap water and deionized water) between individual samples within the same hole to prevent cross-contamination as sampling progressed downward. Stainless steel mixing bowls and spoons used to composite samples were washed and double-rinsed between samples.

2.5 Borehole Abandonment

Each borehole and temporary well was abandoned according to Missouri Well Construction Rules (10 CSR 23) and the specifications outlined in Work Package 533, Task 13. All boreholes and temporary wells constructed in the alluvium were abandoned using either high-solids bentonite grout or 3/8-in chipped bentonite. The polyvinyl chloride (PVC) screen and riser were removed from the temporary wells before abandonment commenced. Generally, if a borehole was more than 15-ft deep, it was pressure-grouted from the bottom to the surface using a tremie pipe. If less than 15 ft, the hole was backfilled to the surface with 3/8-in chipped bentonite and hydrated. Boreholes advanced into the bedrock were grouted from the bottom using a tremie pipe.

2.6 Waste Management

Based on previous soil drilling in the quarry area, it was determined that soil cuttings would not require special handling or disposal. Therefore, the soil cuttings were spread out in the vicinity of the borehole. All soil samples were scanned in the field immediately after retrieval, with only a few small intervals showing above-background activity. Soils that exhibited elevated beta-gamma readings, as measured with a Ludlum 44-9 scintillation detector, were analyzed at the on-site radiological laboratory for waste handling purposes. All water from the drilling of the two bedrock cores was collected in 55-gal drums and disposed of at the facility located at the quarry. Remaining trash was hauled to the quarry area and placed in trash receptacles.

3. ANALYTICAL METHODS

Field and laboratory analysis and testing of soil and groundwater samples were performed as described in the *Sampling Plan* (Ref. 3) and according to established U.S. Environmental Protection Agency (EPA) and American Society for Testing and Materials (ASTM) methods.

3.1 Field Parameters and Analysis

Field parameters (pH, Eh, conductivity, dissolved oxygen, turbidity and temperature) were measured in all groundwater samples using a Horiba U10 water quality checker, in accordance with procedure ES&H 4.4.1 *Groundwater Sampling*. A fresh water sample was withdrawn from the well using the peristaltic pump, placed in a pre-rinsed beaker, and immediately analyzed using the instrument. Concurrent with field parameter testing, the groundwater was also tested for redox-sensitive parameters ferrous iron (Fe^{2+}) and sulfide (S^{2-}) with a Hach DR-2000 field analyzer using instrument methods 8146 and 8131, respectively. These methods are equivalent to or adapted from standard wastewater examination or EPA methods and are included in Appendix B. Readouts from the instrument were recorded in the field book.

3.2 Laboratory Methods

Soil and groundwater samples were analyzed at the off-site contracted analytical laboratory or materials testing facility using the methods specified in Table 3-1.

Table 3-1 Laboratory Analytical Methods

Parameter	Method	Matrix
Uranium (total)	KPA (ASTM D5174)	Water
	Alpha Spectroscopy	Soil
Metals (Fe and Mn)	6010 (SW-846)	Soil
TOC	9060 (SW-846)	Soil
Metals (Ca, Mg, Fe, Al, Mn, K, Na, Si)	6010 (SW-846)	Water
Chloride	EPA 300/325	Water
Sulfate (SO_4)	EPA 300.0	Water
Alkalinity	EPA 310.1	Water
Nitrate	EPA 300/325	Water
Grain size distribution	ASTM D422	Soil
Moisture content	ASTM D2216	Soil
Bulk density	ASTM 2937.	Soil

4. DATA ANALYSIS

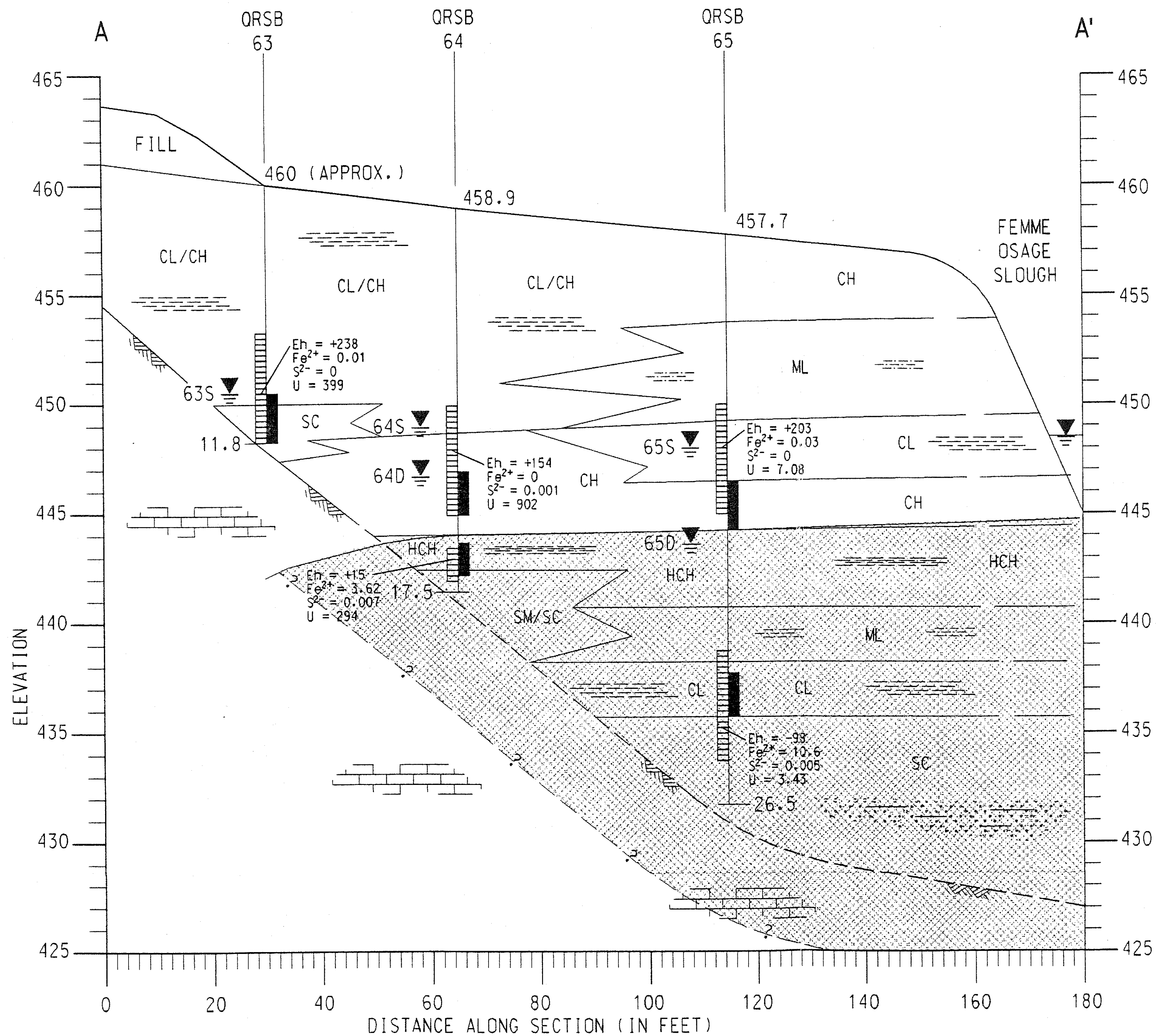
4.1 Hydrogeologic Characterization

Prior to this study, drilling and sampling in the quarry area have provided a significant amount of data to characterize the geology and hydrology of the shallow aquifer. This geochemical sampling program provided additional information to support the conceptualized hydrogeologic framework controlling contaminant fate. Hydrogeologic information obtained during this field study included lithologic descriptions, mineralogy, organic contact, formation contacts and thickness (stratigraphy), engineering soil properties, water levels, and depth to bedrock. Analysis of these data focused on adding to the knowledge base developed from previous drilling programs, such as further characterizing the oxidized/reduced zone contact in three dimensions using the soil descriptions and sample data.

4.1.1 Alluvium

Detailed logging of soil samples was performed to further characterize the lithology of the aquifer matrix and its impact on groundwater flow and contaminant migration. Continuous soil sampling was conducted to allow correlation of alluvium properties between holes. Figures 4-1 through 4-5 are cross sections along each line of boreholes, northwest to southeast, and show the general stratigraphy of the alluvium. The major soil type encountered was low-plasticity clay, with high-plasticity clay, silt, and fine to medium sand making up the other soil types sampled. At locations closer to the slough, the finer grained sediments commonly give way to more granular material, particularly at depth. Also, silty and clayey fine- to medium-grained sand was encountered at the base of the alluvium. Interbedding of different grain-size sediments was typical and included alternating thinly (less than 1 in) bedded clays, silts, and sands. As was the case in previous investigations, correlation of discrete units proved to be difficult because of the fluvial depositional environment represented, although a broad correlation of sediments can be made across the area.

Abundant organic material in the form of roots, twigs, wood chips, leaves, grass stalks, and carbonaceous sand-sized pieces was observed throughout the alluvial section. In the oxidized portion of the alluvium, the organics were commonly replaced with iron oxides, such as limonite and hematite. In the reduced portion, the organics were typically carbonized or coalified. Lignitic clays and lignite were common within the reduced zone.



CROSS SECTION A-A'

LEGEND

64D

Eh = +15 (mV)
Fe^{2+} = 0.03 (mg/l)
S^{2-} = 0 (mg/l)
U = 7.08 (pCi/l)

TEMPORARY WELL SHOWING SCREENED ZONE, WATER LEVEL, WELL DESIGNATION (D=DEEP S=SHALLOW), AND SELECTED PARAMETERS MEASURED.

SOIL SAMPLING INTERVAL

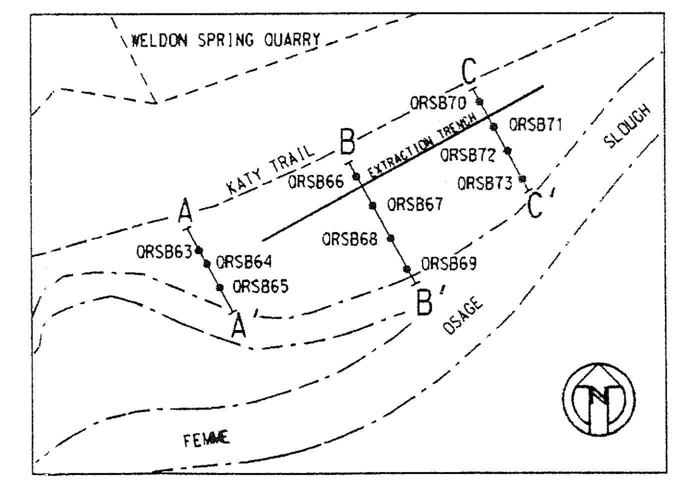
33.5 TOTAL BOREHOLE DEPTH

CL LOW PLASTICITY CLAY
CH HIGH PLASTICITY CLAY
HCH VERY HIGH PLASTICITY CLAY
ML SILT
SM SILTY SAND
SC CLAYEY SAND
SP POORLY GRADED SAND

GEOCHEMICALLY REDUCED ZONE

4X VERTICAL EXAGGERATION

LOCATION MAP

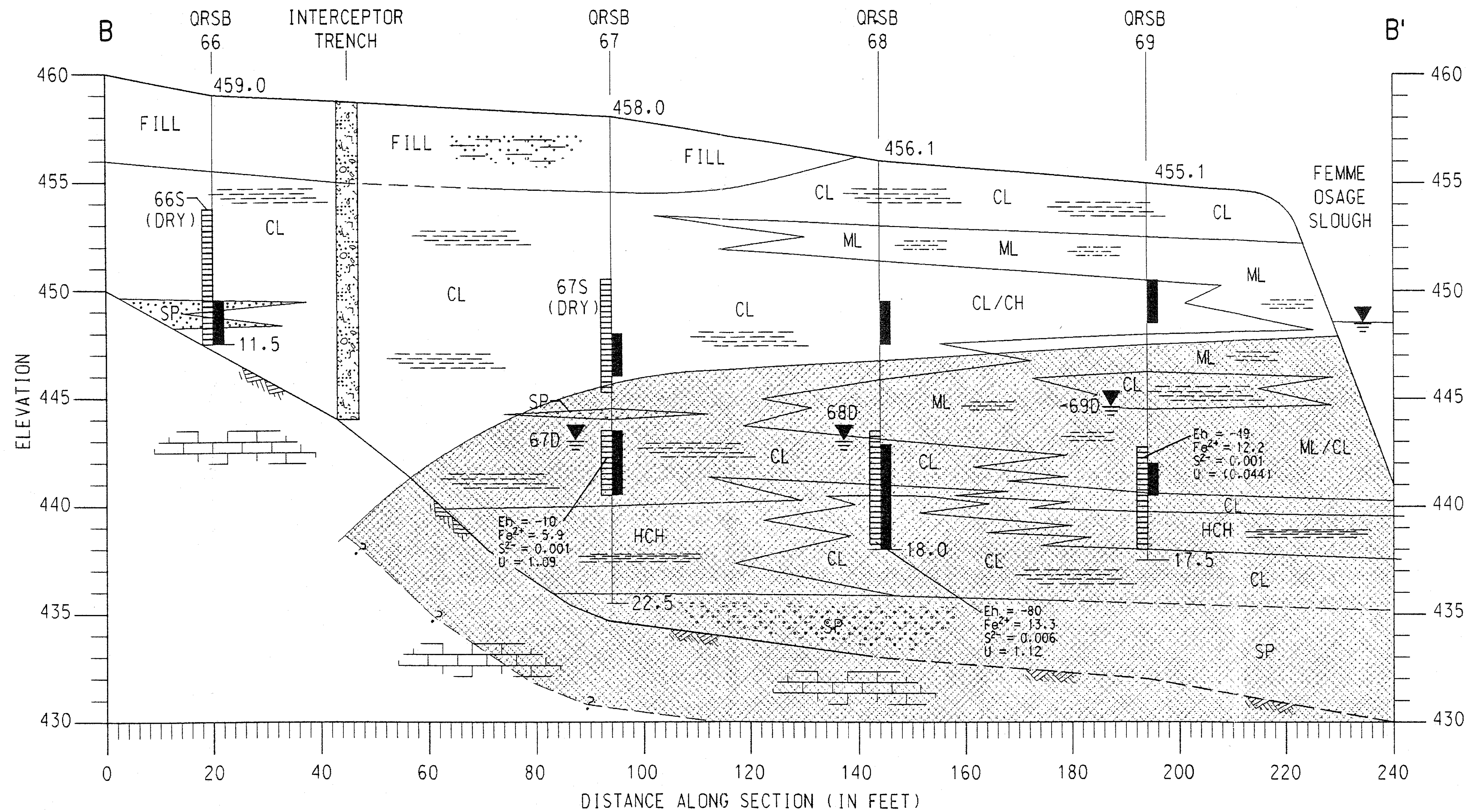


CROSS-SECTION A-A'
GEOCHEMICAL CHARACTERIZATION

FIGURE 4-1

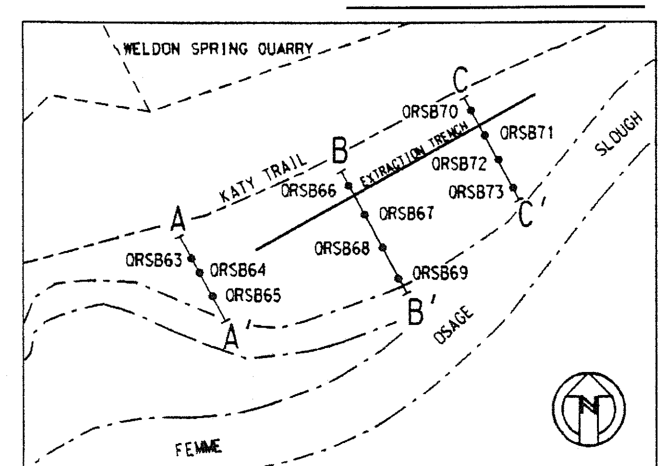
REPORT NO: DOE/OR/21548-919	DRAWING NO: W03840\PPGE053D.DGN

ORIGINATOR: P PATCHIN	DRAWING BY: R PARSONS	DATE: JULY 2002



CROSS SECTION B-B'

LOCATION MAP



LEGEND

64D

Eh = +15 (mV)
Fe^{2+} = 0.03 (mg/l)
S^{2-} = 0 (mg/l)
U = 7.08 (pCi/l)

TEMPORARY WELL SHOWING SCREENED ZONE, WATER LEVEL, WELL DESIGNATION (D=DEEP S=SHALLOW), AND SELECTED PARAMETERS MEASURED.

SOIL SAMPLING INTERVAL

33.5 TOTAL BOREHOLE DEPTH

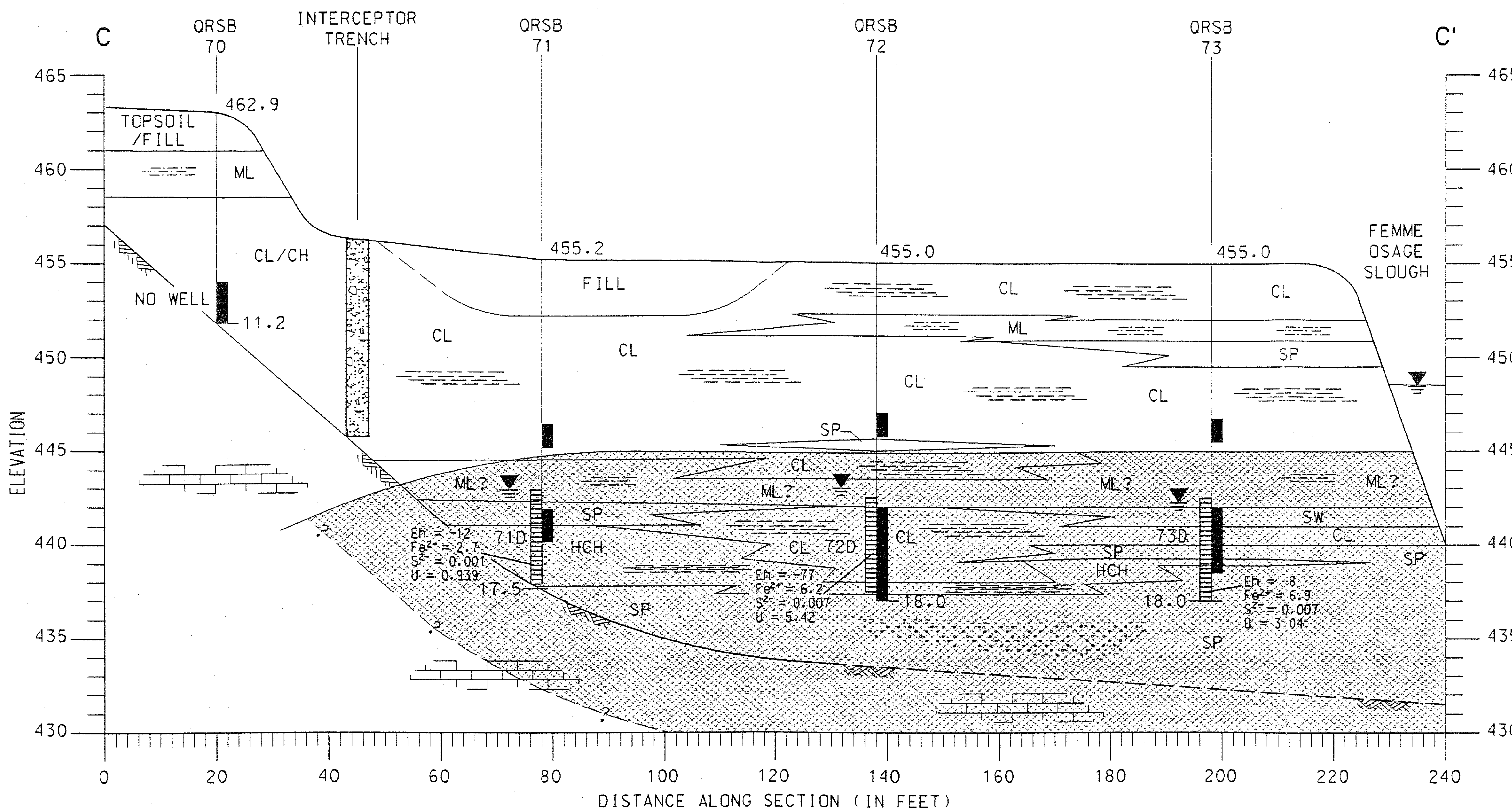
CL	LOW PLASTICITY CLAY
CH	HIGH PLASTICITY CLAY
HCH	VERY HIGH PLASTICITY CLAY
ML	SILT
SM	SILTY SAND
SC	CLAYEY SAND
SP	POORLY GRADED SAND
	GEOCHEMICALLY REDUCED ZONE

4X VERTICAL EXAGGERATION

CROSS-SECTION B-B'
GEOCHEMICAL CHARACTERIZATION

FIGURE 4-2

REPORT NO: DOE/OR/21548-919	DRAWING NO: W03840\PPGE053D.DGN	
ORIGINATOR: P PATCHIN	DRAWING BY: R PARSONS	DATE: JULY 2002



CROSS SECTION C-C'

LEGEND

64D

Eh = +15 (mV)
Fe^{2+} = 0.03 (mg/l)
S^{2-} = 0 (mg/l)
U = 7.08 (pCi/l)

TEMPORARY WELL SHOWING SCREENED ZONE, WATER LEVEL, WELL DESIGNATION (D=DEEP S=SHALLOW), AND SELECTED PARAMETERS MEASURED.

SOIL SAMPLING INTERVAL

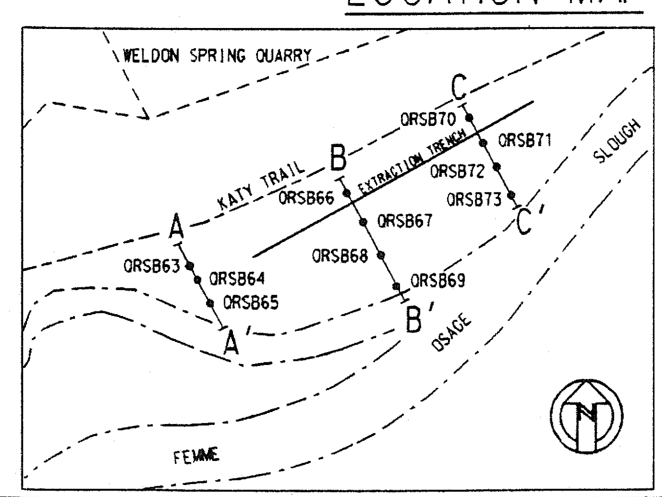
33.5 TOTAL BOREHOLE DEPTH

CL	LOW PLASTICITY CLAY
CH	HIGH PLASTICITY CLAY
HCH	VERY HIGH PLASTICITY CLAY
ML	SILT
SM	SILTY SAND
SC	CLAYEY SAND
SP	POORLY GRADED SAND
SW	WELL GRADED SAND

GEOCHEMICALLY REDUCED ZONE

4X VERTICAL EXAGGERATION

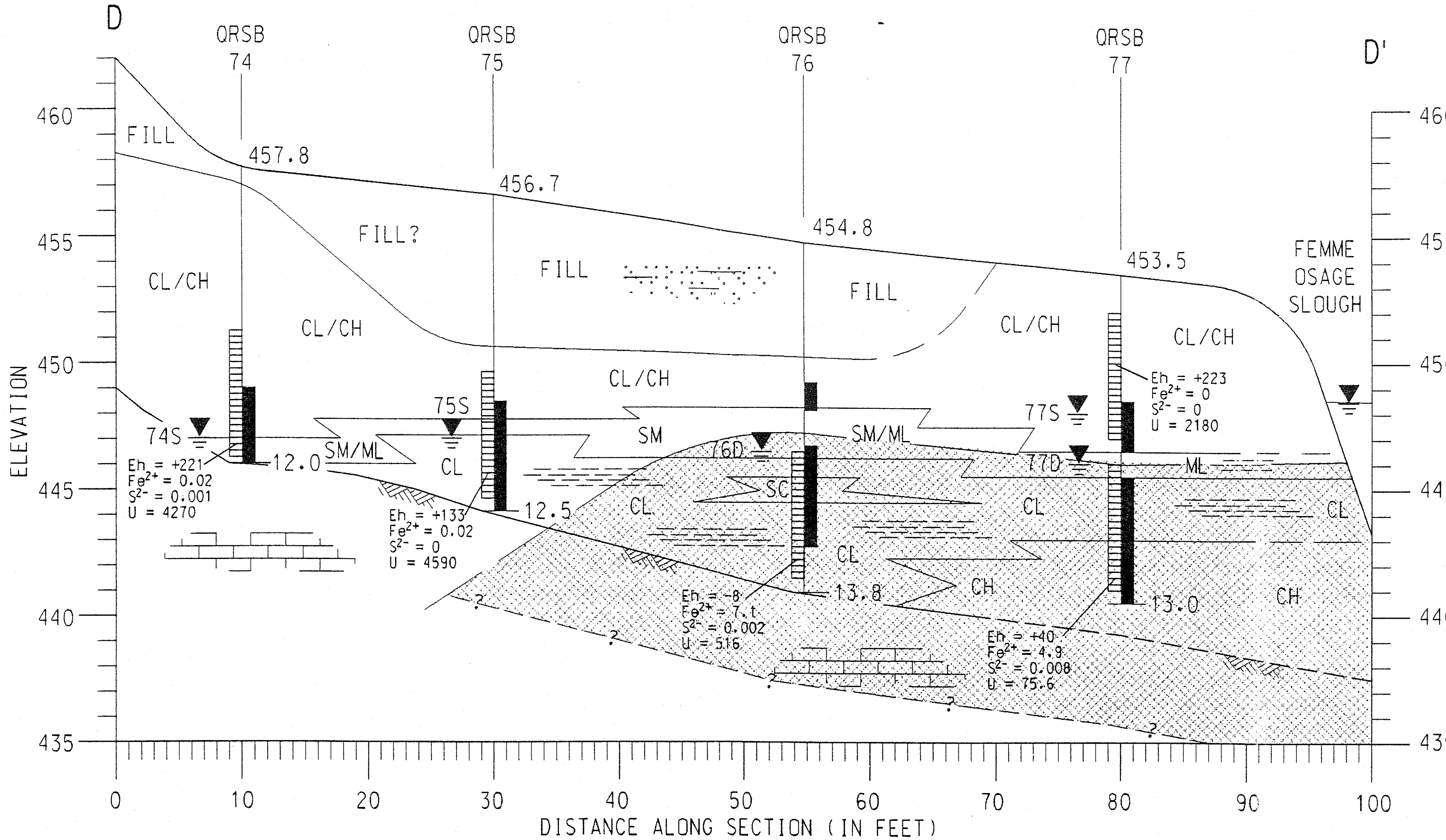
LOCATION MAP



CROSS-SECTION C-C'
GEOCHEMICAL CHARACTERIZATION

FIGURE 4-3

REPORT NO: DOE/OR/21548-919	DRAWING NO: W03840\PPGE053D.DGN	
ORIGINATOR: P PATCHIN	DRAWING BY: R PARSONS	DATE: JULY 2002



CROSS SECTION D-D'

LEGEND

Eh = +15 (mV)
Fe^{2+} = 0.03 (mg/l)
S^{2-} = 0 (mg/l)
U = 7.08 (pCi/l)

64D

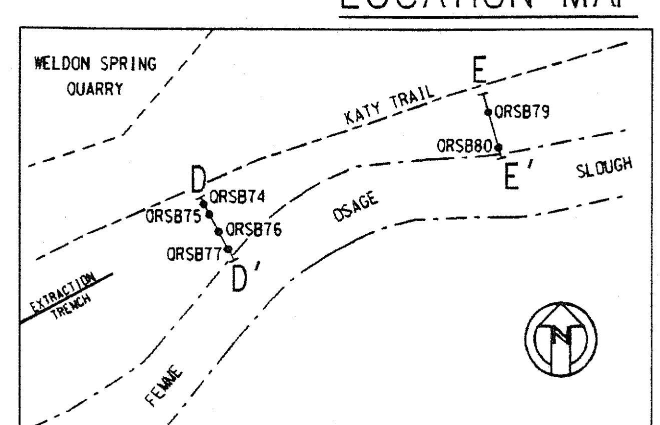
TEMPORARY WELL SHOWING SCREENED ZONE, WATER LEVEL, WELL DESIGNATION (D=DEEP S=SHALLOW), AND SELECTED PARAMETERS MEASURED.

SOIL SAMPLING INTERVAL

33.5 TOTAL BOREHOLE DEPTH

CL	LOW PLASTICITY CLAY
CH	HIGH PLASTICITY CLAY
HCH	VERY HIGH PLASTICITY CLAY
ML	SILT
SM	SILTY SAND
SC	CLAYEY SAND
SP	POORLY GRADED SAND
	GEOCHEMICALLY REDUCED ZONE
	2X VERTICAL EXAGGERATION

LOCATION MAP

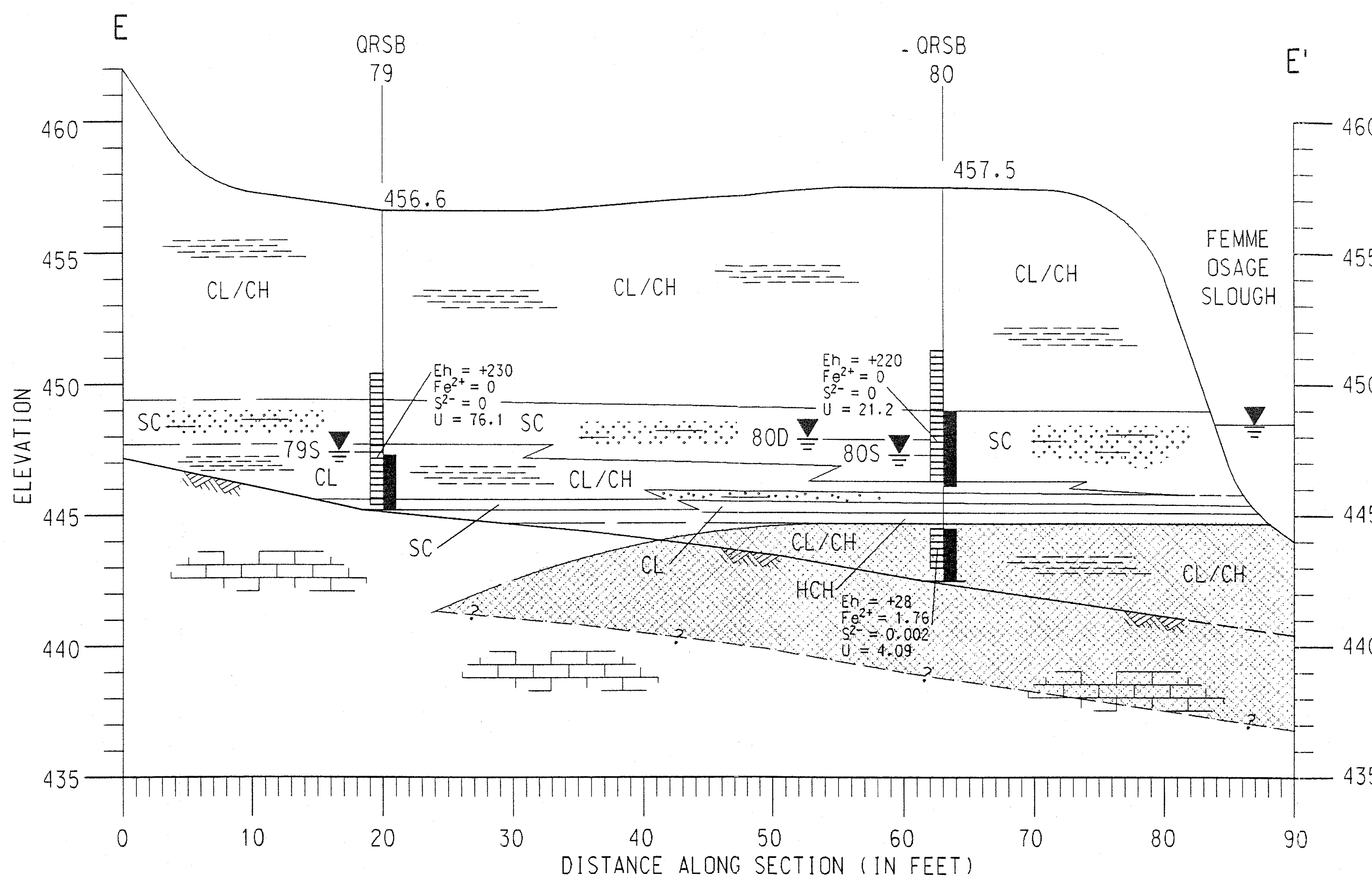


CROSS-SECTION D-D'

GEOCHEMICAL CHARACTERIZATION

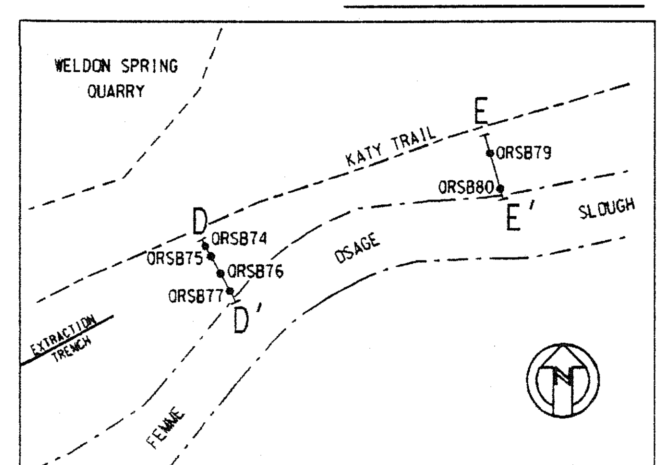
FIGURE 4-4

REPORT NO: DOE/OR/21548-919		DRAWING NO: W03840\PPGE053D.DGN
ORIGINATOR: P PATCHIN	DRAWING BY: R PARSONS	DATE: JULY 2002



CROSS SECTION E-E'

LOCATION MAP



LEGEND

64D

Eh = +15 (mV)
Fe^{2+} = 0.03 (mg/l)
S^{2-} = 0 (mg/l)
U = 7.08 (pCi/l)

TEMPORARY WELL SHOWING SCREENED ZONE, WATER LEVEL, WELL DESIGNATION (D=DEEP S=SHALLOW), AND SELECTED PARAMETERS MEASURED.

SOIL SAMPLING INTERVAL

33.5 TOTAL BOREHOLE DEPTH

CL	LOW PLASTICITY CLAY
CH	HIGH PLASTICITY CLAY
HCH	VERY HIGH PLASTICITY CLAY
ML	SILT
SM	SILTY SAND
SC	CLAYEY SAND
SP	POORLY GRADED SAND

GEOCHEMICALLY REDUCED ZONE

2X VERTICAL EXAGGERATION

CROSS-SECTION E-E'
GEOCHEMICAL CHARACTERIZATION

FIGURE 4-5

REPORT NO: DOE/OR/21548-919	DRAWING NO: W03840\PPGE053D.DGN

ORIGINATOR: P PATCHIN	DRAWING BY: R PARSONS	DATE: JULY 2002

A distinct contact was evident across the site separating alluvial soils with characteristics indicative of oxidized conditions from those indicating reduced conditions. This oxidized/reduced zone contact was also documented during earlier studies (Ref. 2), and those observations remain consistent with those of this fieldwork. The oxidized/reduced zone contact is characterized as a change in the physical characteristics of the alluvial material with depth, most notably in the form of a color change from primarily yellow/browns to gray/blacks. Other indicators are the presence or absence of iron oxides such as limonite and hematite (oxidized zone) or carbonized or coalified organic material (reduced zone). In addition, soil in the reduced zone commonly has a hydrogen sulfide (H_2S) smell.

The transition from the oxidizing to reducing conditions can either be sharp or gradational, occurring over a few inches up to a few feet. For example, in some boreholes, it was evident that the contact had been "smeared" by fluctuating water levels. Samples from borehole QRSB-80 showed clay from the reduced zone adjacent to the contact, which was primarily dark gray and exhibited yellowish-brown iron oxide "spotting" within the dark gray clay matrix. This is likely the result of seasonal fluctuations in water level (Section 4.1.3), although the stratigraphy and grain size of the sediments can also influence whether the contact is gradational or sharp.

Selected soil samples were tested to determine the grain size distribution and bulk density in the oxidized portion of the alluvium. Grain-size distribution testing allowed correlation of the sorption capacity and soil type (Section 4.4) while the bulk-density testing results were used to determine the sorbed uranium mass. Table 4-1 presents the results of the geotechnical testing.

Table 4-1 Summary of Geotechnical Testing Results

Sample ID	Interval (ft)[1]	Gradation			Water Content (%)	Bulk Density (g/cm^3)	USCS Classification[2]
		% Sand	% Silt	% Clay			
QRSB-63	9.5 – 12.0	7	75	18	35	1.36	SC (CH)
QRSB-64	12.0 – 14.0	1	28	71	39	1.28	CH
QRSB-65	11.0 – 13.0	1	31	68	43	1.25	CH
QRSB-66	9.5 – 11.5	66	16	18	14	NA	SP (CL)
QRSB-67	10.0 – 12.0	25	57	25	30	1.44	CL
QRSB-72	8.0 – 9.2	3	72	25	31	1.43	CL
QRSB-74	9.5 – 12.0	3	34	63	37	1.33	CL (ML)
QRSB-75	10.0 – 12.5	5	75	25	33	1.41	CL (ML)
QRSB-79	9.4 – 11.4	4	64	32	35	1.36	CL
QRSB-80	9.0 – 11.5	1	27	72	41	1.27	SC (CL)

NA Not analyzed
Note: 1 Depth measured below ground surface
2 Classification determined in the field. Classification in parentheses denotes secondary soil type.

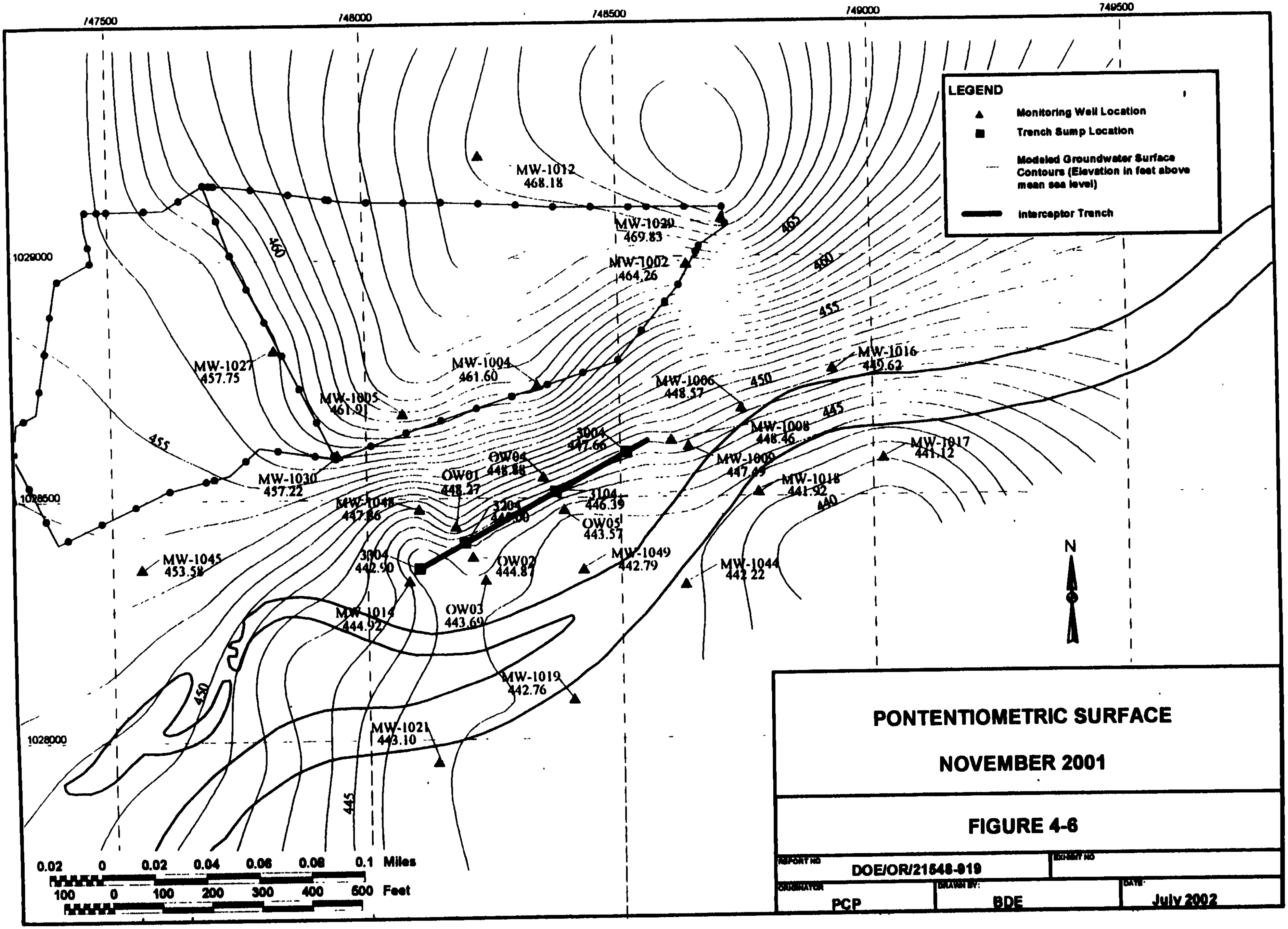
4.1.2 Bedrock

Two boreholes were drilled into bedrock (QRSB-81 and 82) to obtain bedrock samples for determining the distribution coefficient (K_d) for the Decorah Group limestone. These boreholes were drilled immediately adjacent to existing monitoring wells OW-1 and OW-4, respectively, to allow for the collection of groundwater samples that are representative of the sampled bedrock core without installing new wells. The core was described in accordance with procedure ES&H 4.4.7, *Soil, Rock Core, and Rock Chip Borehole Logging* with the exception of describing fractures (Appendix A). The borehole logs from adjacent monitoring wells were relied upon for fracture information.

4.1.3 Groundwater Levels

Water levels were measured in the temporary wells that were installed during this study. Water levels were generally lower compared to other months, because the fieldwork was performed during November, which is normally a lower water period. The interceptor trench was also operating, which locally affects (lowers) the water surface. Figure 4-6 shows the water levels measured during the study period. The effect of the operation of the quarry interceptor trench on the groundwater surface can be seen, with capture shown particularly in the western part of the study area. Again, this effect is somewhat attenuated compared to other months because of the low seasonal water levels.

Water levels measured in the temporary wells are shown in cross section on Figures 4-1 through 4-5. In the four locations (QRSB-64, 65, 77, and 80) where discrete zone screening and sampling of both the oxidized and reduced zone groundwater was performed, the water levels were different between the shallow and deeper well. This phenomenon can be most easily seen in the westernmost line of boreholes (Figure 4-1) where two water levels were measured at the same site, indicating a perched or semi-perched condition for the upper water. Location QRSB-65 shows the greatest difference in water levels between the shallow and deep-screened zones at 4.4 ft, while QRSB-64 showed the least at 1.7 ft. At QRSB-80, the deeper, reduced zone well exhibited a slightly higher water level than the more shallow-screened, oxidized zone well at the same location. The may be the result of self-confining conditions within the lower sediments on a localized scale.



PONTENTIOMETRIC SURFACE

NOVEMBER 2001

FIGURE 4-6

REPORT NO	EXHIBIT NO	
DOE/OR/21548-919		
ORIGINATOR: PCP	DRAWN BY: BDE	DATE: July 2002

Water level fluctuations occur in the quarry area due to natural variation in aquifer recharge, in addition to the effect of pumping of the quarry interceptor trench (Ref. 5). Groundwater levels can fluctuate up to 10 ft in most alluvial wells in the study area. Extreme water levels are the result of large precipitation events or extreme river levels (e.g., flooding). A correlation has been made between the Missouri River levels and the water table in the alluvium north of the slough. When the river levels are up or down, these levels are reflected shortly in the groundwater levels north of the slough. Missouri River levels may be affected by precipitation events great distances away from the quarry area so may not necessarily be coincidental with local precipitation events (Ref. 5).

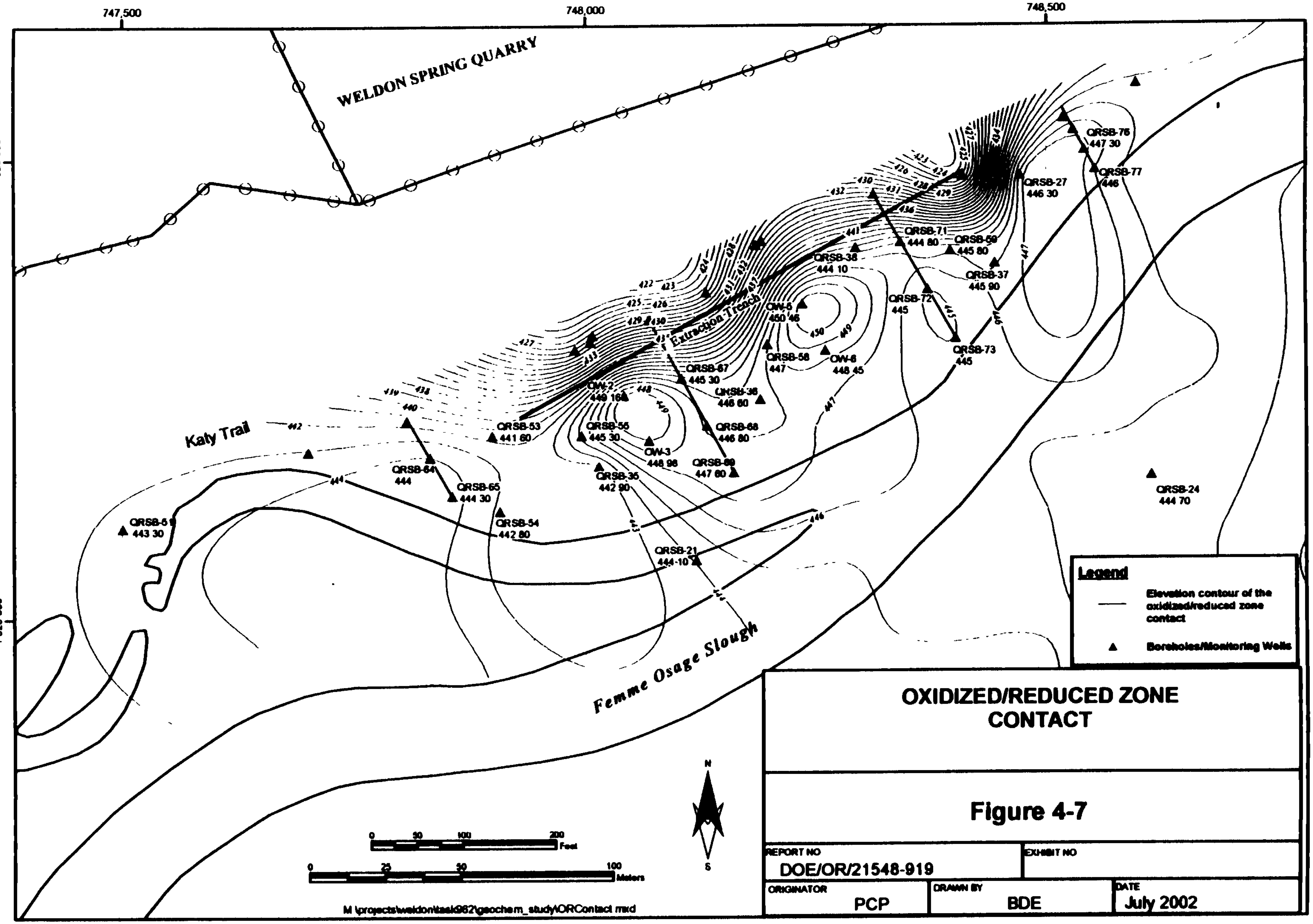
4.2 Geochemical Characterization

As has been described in previous studies (Ref. 2), a distinct separation between upgradient (and shallow) oxidizing conditions and downgradient (and deeper) reducing conditions has been noted in field descriptions of soil core samples and groundwater chemistry data. This "redox front" is described in drill core samples from this and previous studies as a distinct contact observed in boreholes starting approximately a third of the distance from the Katy trail to the slough. Figures 4-1 through 4-5 show the approximate location of the redox front in cross section. Figure 4-7 is a plan view of the area showing elevation contours on the contact surface. As noted in the Section 4.1.1, the front is distinguished by an abrupt color change from tan/brown to gray/black. "Above" the front, in the oxidizing zone, limonite and hematite have replaced organic material in the alluvium, while below the front; organic material was not substantially decomposed but was instead commonly carbonized or coalified.

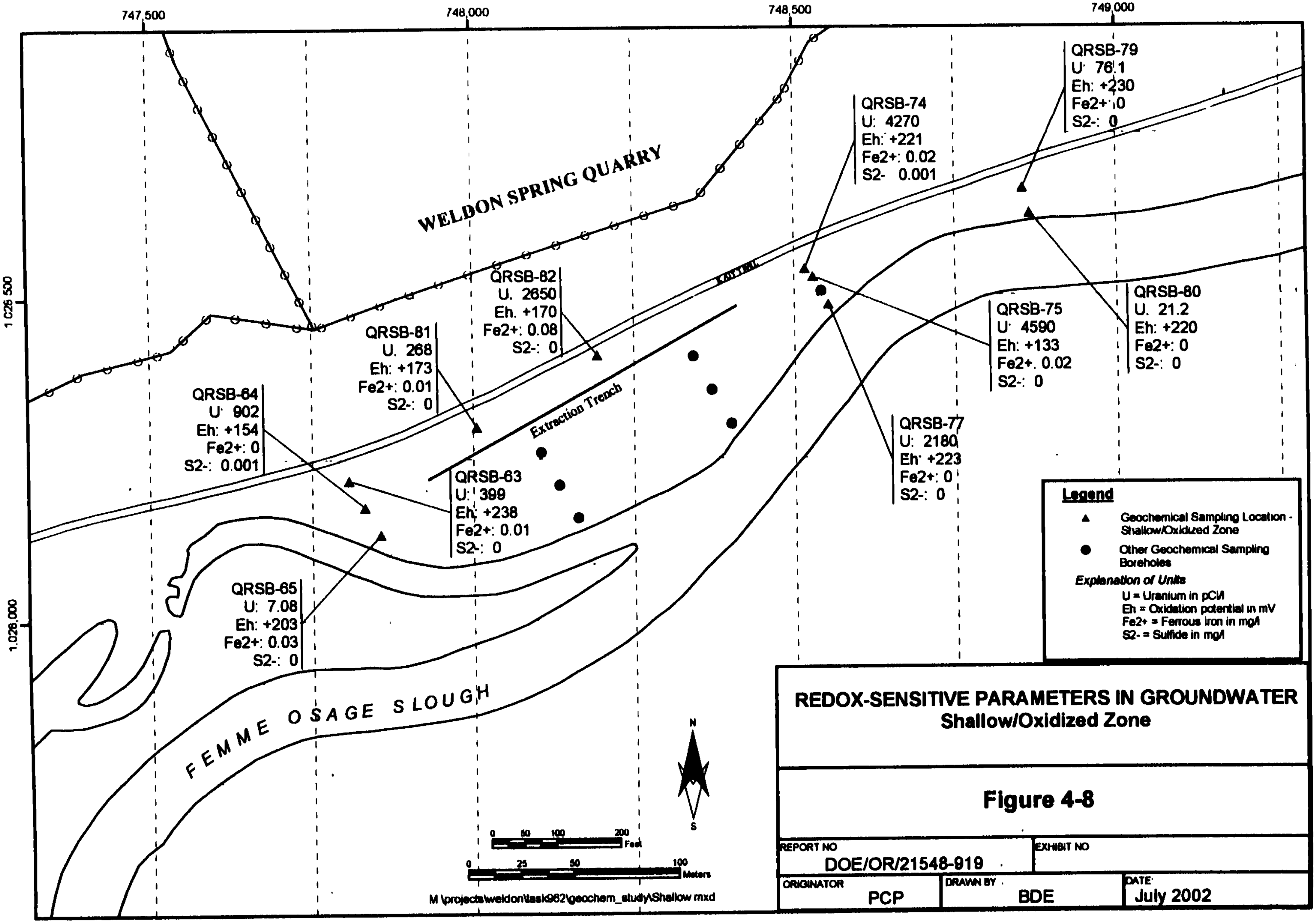
Reducing conditions likely exist in the upper, fractured bedrock immediately underlying the reduced portions of the alluvium. Aquifer testing and water level measurements indicate that the upper 5 ft. to 7 ft. of the Decorah Group and the overlying alluvium are hydraulically connected (Ref. 9). The oxidation state deeper into the Decorah Group and in the underlying Plattin Formation is influenced by upward recharge from the underlying bedrock units, which exhibit oxidizing conditions.

Geochemical data indicating the presence of a redox front support these field observations. Discrete groundwater samples were collected from wells that were screened to isolate zones above and below the point where field observations indicated the redox front was located. Because of the lower water levels, only four of the well locations had water levels that extended high enough to allow samples to be collected from both the reducing and oxidizing zones at the same location. In other wells, groundwater levels indicated that saturation existed either entirely in oxidizing or entirely in reducing conditions. Groundwater samples were analyzed for redox-sensitive parameters summarized in Sections 3.1 and 3.2. Figures 4-1 through 4-5 show the results from these analyses for each well sampled. Notice the distinct difference in results from those wells screened in the upper oxidized zone and those screened in the deeper reduced zone. Figures 4-8 and 4-9 show the aerial distribution of these parameters as measured in groundwater from the oxidized and reduced zones respectively.

In all cases, the initial determination of reducing versus oxidizing zones was based on field observations. For the purposes of field identification and discussion, samples from the oxidizing zone were denoted as "shallow," while samples from the reducing zone were denoted as "deep." Results for individual parameters and parameter pairs are described below. Analytical data are presented in Appendix C.

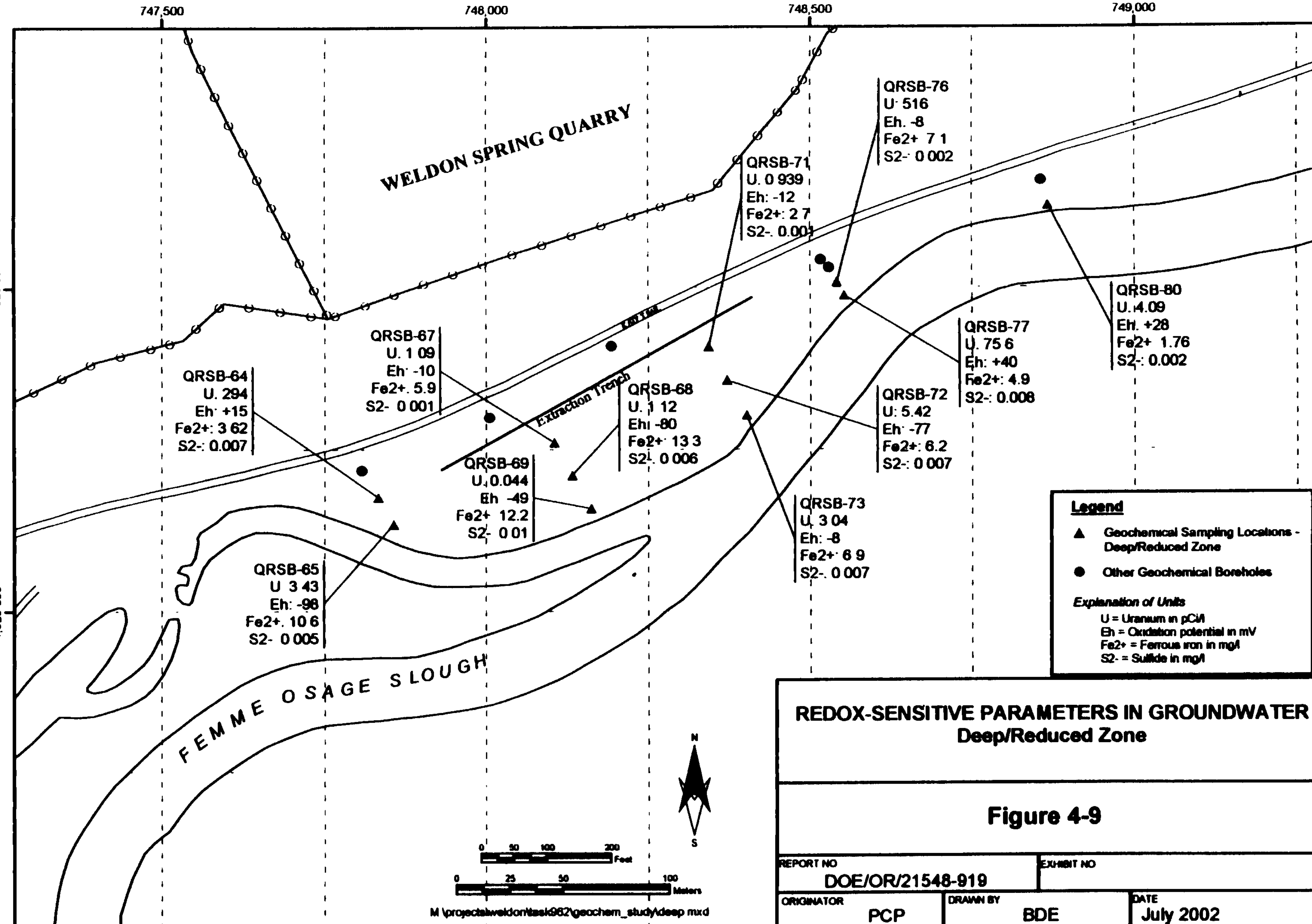


747,500
748,000
748,500
1 028 500
1 028 000
WELDON SPRING QUARRY
Extraction Trench
Katy Trail
Femme Osage Slough
QRSB-76
447 30
QRSB-77
446
QRSB-27
446 30
QRSB-71
444 80
QRSB-59
445 80
QRSB-38
444 10
QRSB-37
445 90
QRSB-72
445
OW-5
450 46
QRSB-73
445
QRSB-58
447
OW-6
448 45
QRSB-67
445 30
QRSB-36
446 60
OW-2
449 16
QRSB-53
441 60
QRSB-55
445 30
QRSB-68
446 80
OW-3
448 98
QRSB-69
447 60
QRSB-64
444
QRSB-65
444 30
QRSB-35
442 90
QRSB-24
444 70
QRSB-51
443 30
QRSB-54
442 80
QRSB-21
444 10
Legend
Elevation contour of the oxidized/reduced zone contact
Boreholes/Monitoring Wells
N
S
0 50 100 200 Feet
0 25 50 100 Meters
M \projects\weldon\task962\geochem_study\ORContact mxd
OXIDIZED/REDUCED ZONE CONTACT
Figure 4-7
REPORT NO
DOE/OR/21548-919
EXHIBIT NO
ORIGINATOR
PCP
DRAWN BY
BDE
DATE
July 2002



REDOX-SENSITIVE PARAMETERS IN GROUNDWATER
Shallow/Oxidized Zone

Figure 4-8



REDOX-SENSITIVE PARAMETERS IN GROUNDWATER
Deep/Reduced Zone

Figure 4-9

REPORT NO	EXHIBIT NO	
DOE/OR/21548-919		
ORIGINATOR: PCP	DRAWN BY: BDE	DATE: July 2002

4.2.1 Eh/Dissolved Oxygen

Eh and dissolved oxygen are direct indicators of oxidation state. Eh is a measure of the activity of the electrons in solution by which oxidation-reduction reactions occur, and dissolved oxygen is a direct measurement of the concentration of molecular oxygen in solution. Eh and dissolved oxygen were measured in groundwater samples by the methods described in Section 3.1. Eh data are summarized in Table 4-2.

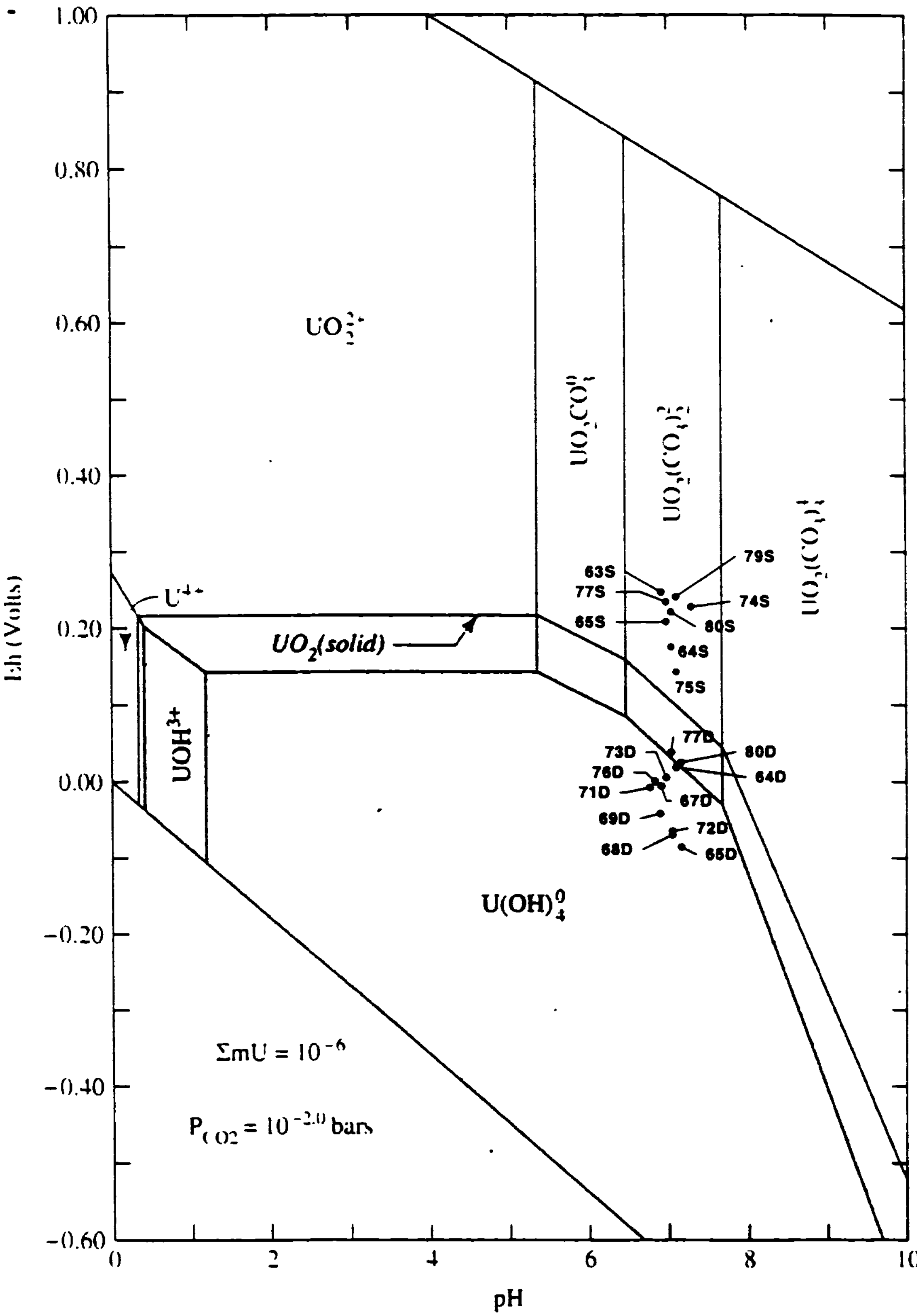
Table 4-2 Eh Measurements

Well ID	Eh (milliVolts)	
	Shallow	Deep
QRSB-63	+238	NA
QRSB-64	+154	+15
QRSB-65	+203	-98
QRSB-67	NA	-10
QRSB-68	NA	-80
QRSB-69	NA	-49
QRSB-71	NA	-12
QRSB-72	NA	-77
QRSB-73	NA	-8
QRSB-74	+221	NA
QRSB-75	+133	NA
QRSB-76	NA	-8
QRSB-77	+223	+40
QRSB-79	+230	NA
QRSB-80	+220	+28

NA not analyzed – zone unsaturated

Eh measurements in deep samples ranged from –98 to +40 mV, while Eh measurements from shallow samples ranged from +154 to +223 mV. These values are consistent with reducing and oxidizing environments, respectively. For reference, uranium reduction and precipitation has been demonstrated (under laboratory conditions simulating similar environments) as Eh levels decrease below about 100 mV (Ref. 6) (Figure 4-10). The four paired samples from shallow and deep intervals in single wells also clearly showed the transition to reducing conditions with depth, with Eh measurements decreasing by approximately 150 to 300 mV between sample pairs (Figures 4-1, 4-3, and 4-4).

Dissolved oxygen measurements were inconclusive. Dissolved oxygen in shallow samples ranged from 2.1 to 4.6 mg/L, while deep samples measured from 1.79 to 5.56 mg/L. Unlike Eh and other redox-sensitive parameters, there is no clear distinction between dissolved oxygen levels from shallow and deep samples. This is probably the result of rapid oxidation of the sample while the dissolved oxygen was being measured. Dissolved oxygen measurements were determined on samples collected in an open beaker (Section 3.1), while the other redox-sensitive parameters were collected and tested in closed containers with minimal headspace.



Eh-pH Diagram for Uranium Showing Groundwater Sample Values. Source: J. Giridhar and Donald Langmuir, *Radiochimica Acta* 54:133-38, 1991.

Eh-pH DIAGRAM URANIUM	
FIGURE 4-10	
DOE/OR/21548-919	
	AUGUST 2002

It is likely that the open container resulted in greater aeration than the other samples, thereby producing unrepresentative dissolved oxygen measurements. This is evident from the relatively high levels of dissolved oxygen in the deep samples, which are higher than expected for reducing conditions. That is, since reducing conditions cannot exist with dissolved oxygen greater than about 1 mg/L, the deep samples with higher measurements must have been oxidized during sampling.

4.2.2 Dissolved Iron

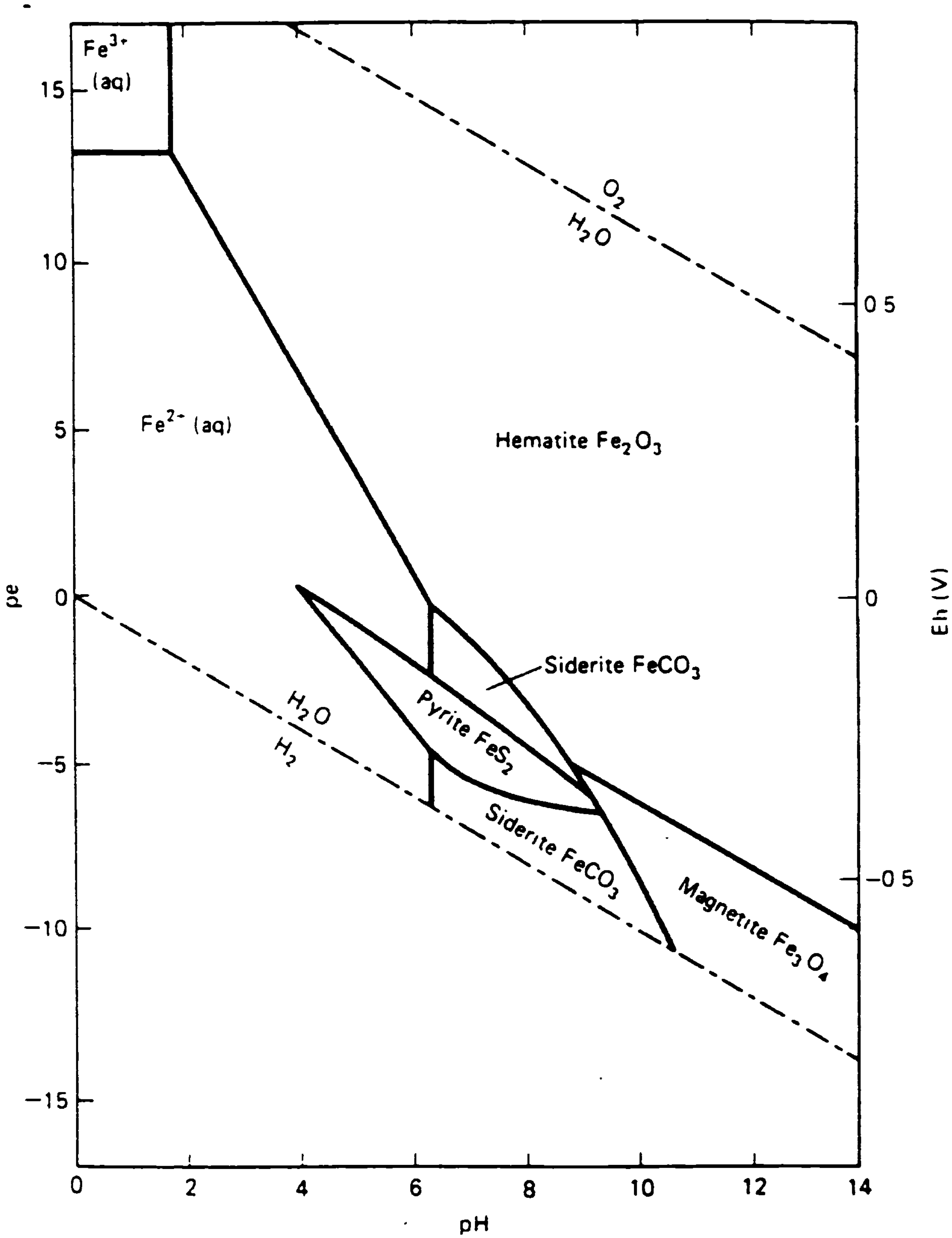
Iron occurs in groundwater as either reduced ferrous iron (Fe^{2+}) or oxidized ferric iron (Fe^{3+}). Ferric iron, stable under oxidizing conditions, rapidly precipitates as the common iron oxides and hydroxides and consequently, is relatively immobile and dissolved concentrations in oxidized water are relatively low. Conversely, ferrous iron is very soluble under reducing conditions, and high concentrations of ferrous iron commonly occur in equilibrium with sulfide mineral precipitation. Any dissolved ferrous iron that re-enters oxidizing conditions is rapidly oxidized and precipitated as iron oxyhydroxides (Figure 4-11).

Total and ferrous iron were measured in groundwater samples using the methods described in Sections 3.1 and 3.2 and the data are summarized in Table 4-3. Total iron concentrations from shallow samples were very low, ranging from 0.005 mg/L to 0.019 mg/L, while total iron from deep samples ranged from 4.7 to 41.7 mg/L which is consistent with precipitation of oxyhydroxides in the shallow oxidizing zone and high concentrations of dissolved ferrous iron in the deeper reducing zone.

Table 4-3 Dissolved Total Iron and Ferrous Ion in Groundwater

Borehole	Shallow		Deep	
	Total Iron (mg/L)	Fe^{2+} (mg/L)	Total Iron (mg/L)	Fe^{2+} (mg/L)
QRSB-63	15600	0.01	NA	NA
QRSB-64	26000	ND	15800	3.62
QRSB-65	29400	0.03	10400	10.6
QRSB-67	NA	NA	15600	5.9
QRSB-68	NA	NA	NA	13.3
QRSB-69	NA	NA	NA[1]	12.2
QRSB-71	NA	NA	8930	2.7
QRSB-72	NA	NA	29100	6.2
QRSB-73	NA	NA	22700	6.9
QRSB-74	NA[1]	0.02	NA	NA
QRSB-75	< 2.24	0.02	NA	NA
QRSB-76	NA	NA	18100	7.1
QRSB-77	5.72	ND	17000	4.9
QRSB-79	< 2.24	ND	NA	NA
QRSB-80	18.3	ND	793	1.76

NA not analyzed – zone unsaturated
ND non-detect
1 not analyzed as per sampling plan.



Eh – pH Diagram – Iron . Source: James I. Drever, *The Geochemistry of Natural Waters*, Second Ed., 1988.

Eh-pH DIAGRAM IRON	
FIGURE 4-11	
DOE/OR/21548-919	
	AUGUST 2002

The measured ferrous iron concentrations in the deep zone are evidence for a reducing environment. Ferrous iron concentrations in shallow samples ranged from non-detectable to 0.08 mg/L, while concentrations from deep samples ranged from 2.7 mg/L to 13.3 mg/L. Again, these data indicate reducing conditions in the deep samples and oxidizing conditions in the shallow samples.

4.2.3 Dissolved Manganese

Manganese behaves similarly to iron in groundwater. Manganese occurs both in reduced (Mn^{2+}) and oxidized (Mn^{3+} and Mn^{4+}) forms. Oxidized manganese rapidly precipitates as the stable manganese oxides and hydroxides, and equilibrium-dissolved concentrations are relatively low. Conversely, reduced manganese is very soluble, and high concentrations of manganese are commonly observed under reducing conditions.

Total manganese was measured in groundwater samples using the methods described in Sections 3.1 and 3.2 and the data are summarized in Table 4-4. Manganese concentrations from shallow samples were very low, ranging from 0.001 mg/L to 0.008 mg/L, while manganese from deep samples ranged from 1.1 to 4.0 mg/L, which is consistent with precipitation of oxyhydroxides in the shallow oxidizing zone and high dissolved manganese in the deeper reducing zone. Thus, the measured total manganese concentrations mirror the trend observed in iron, providing additional evidence for a deep reducing environment.

Table 4-4 Total Dissolved Manganese in Groundwater

Well ID	Total Dissolved Manganese (mg/l)	
	Shallow	Deep
QRSB-63	0.008	NA
QRSB-64	0.003	1.1
QRSB-65	0.002	1.5
QRSB-67	NA	3.3
QRSB-68	NA	NA
QRSB-69	NA	2.1
QRSB-71	NA	4.0
QRSB-72	NA	2.1
QRSB-73	NA	3.1
QRSB-74	NA	NA
QRSB-75	0.001	NA
QRSB-76	NA	2.7
QRSB-77	0.007	3.7
QRSB-79	0.002	NA
QRSB-80	0.004	1.3

NA not analyzed – zone unsaturated

4.2.4 Sulfate and Sulfide

The oxidized and reduced species of sulfur are also reliable indicators of redox conditions. Under oxidizing conditions, all sulfur will be present as dissolved sulfate (SO_4^{2-}), while under reducing conditions, sulfur is rapidly reduced to insoluble sulfide species, predominantly hydrogen sulfide. Figure 4-12 is a diagram showing the various phases of sulfur relative to Eh and pH of groundwater.

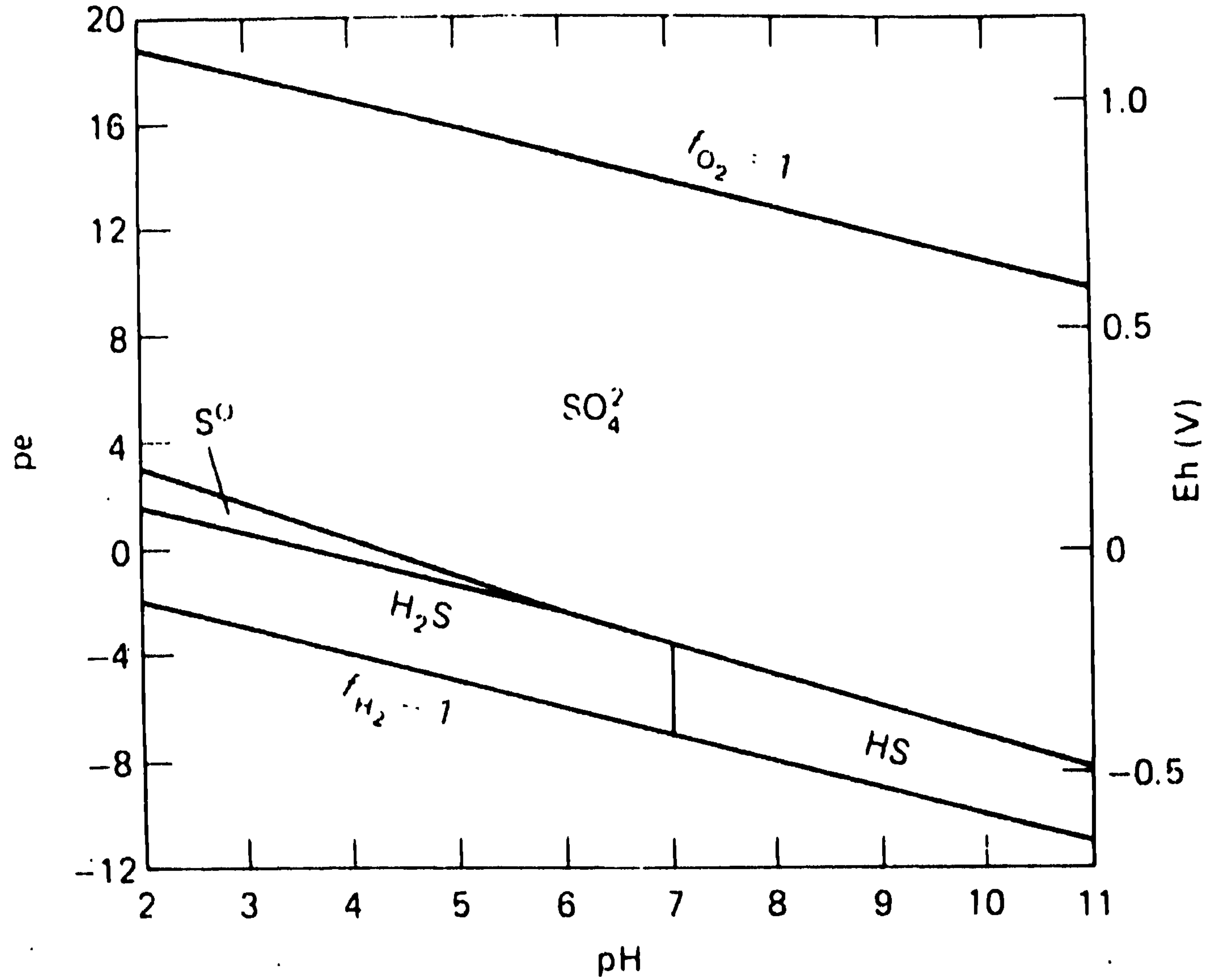
Sulfate and sulfide were measured in groundwater samples using the methods described in Sections 3.1 and 3.2 and the data are summarized in Table 4-5. Sulfate concentrations from shallow samples ranged from 83.4 mg/L to 191 mg/L, while concentrations from deep samples varied from non-detect to 121 mg/L, which is again consistent with oxidizing conditions in the shallow samples and reducing conditions in the deep samples.

Table 4-5 Dissolved Sulfate and Sulfide in Groundwater

Well ID	Shallow		Deep	
	Sulfate (SO_4) (mg/L)	Sulfide (S^{2-}) (mg/L)	Sulfate (SO_4) (mg/L)	Sulfide (S^{2-}) (mg/L)
QRSB-63	191.0	ND	NA	NA
QRSB-64	140.0	0.001	121.0	0.007
QRSB-65	83.4	ND	91.7	0.005
QRSB-67	NA	NA	80.0	0.001
QRSB-68	NA	NA	NA[1]	0.006
QRSB-69	NA	NA	< 0.062	0.010
QRSB-71	NA	NA	1.9	0.001
QRSB-72	NA	NA	0.624	0.007
QRSB-73	NA	NA	22.7	0.007
QRSB-74	NA[1]	0.001	NA	NA
QRSB-75	107.0	ND	NA	NA
QRSB-76	NA	NA	43.6	0.002
QRSB-77	84.9	ND	16.6	0.008
QRSB-79	125.0	ND	NA	NA
QRSB-80	58.3	ND	120.0	0.002

NA not analyzed – zone unsaturated
ND non-detect
1 not analyzed as per sampling plan.

Sulfide also reflects the presence of a reducing zone at depth. Dissolved sulfide is essentially non-existent in shallow samples, measuring 0.001 mg/L in two samples, but in most cases was not detected. Conversely, sulfide in deep samples ranged from 0.001 to 0.008 mg/L. These levels are consistent with concentrations in equilibrium with sulfide minerals and/or hydrogen sulfide (H_2S) gas.



Eh-pH Diagram - Sulfur. Source: James I. Drever, *The Geochemistry of Natural Waters*, Second Ed., 1988.

Eh-pH DIAGRAM SULFUR	
FIGURE 4-12	
DOE/OR/21548-919	
	AUGUST 2002

4.2.5 Uranium

Dissolved uranium is also a good indicator of redox conditions. As has been noted in several studies (Refs. 6 and 7), at near neutral pH under reducing conditions, uranium precipitates as stable uranium oxides (uraninite) and hydroxides (Figure 4-10). The solubility of dissolved uranium in equilibrium with uraninite is very low, on the order of a few parts per billion (ppb), although the exact solubility depends on the complexing species present.

Dissolved uranium was measured in groundwater samples using the methods described in Section 3.2 and the data are summarized in Table 4-6. Uranium concentrations from shallow samples ranged from 7.08 pCi/L to 4590 pCi/L, while concentrations from deep samples ranged from non-detect to 516 pCi/L.

Table 4-6 Dissolved Uranium in Groundwater

Well ID	Dissolved Uranium (pCi/l)	
	Shallow	Deep
QRSB-63	399	NA
QRSB-64	902	294
QRSB-65	7.08	3.43
QRSB-67	NA	1.09
QRSB-68	NA	1.12
QRSB-69	NA	[0.044]
QRSB-71	NA	0.939
QRSB-72	NA	5.42
QRSB-73	NA	3.04
QRSB-74	4270	NA
QRSB-75	4590	NA
QRSB-76	NA	516
QRSB-77	2180	75.6
QRSB-79	76.1	NA
QRSB-80	21.2	4.09

NA not analyzed – zone unsaturated

The uranium data are also consistent with oxidizing conditions within the shallow alluvium, in which uranium is highly soluble and mobile. In the deeper alluvium, reducing conditions are prevalent, and dissolved uranium is reduced to very low levels as uranium is precipitated as insoluble uraninite. This is not to say that sorption of uranium is not also occurring, as discussed in Section 4.4, but that under reducing conditions uraninite precipitation is the dominant process controlling dissolved uranium concentrations in groundwater. This is also supported by the uranium distribution in soil at QRSB-77 as discussed in Section 4.5.2, which shows that uranium in soil is concentrated in a narrow interval (0.2 ft).

Deep samples from QRSB-64, QRSB-76, and QRSB-77 showed much higher levels of uranium than other deep samples. These levels are also higher than predicted for dissolved uranium under reducing conditions in equilibrium with precipitated uraninite. Possible explanations for this may be some mixing of shallow and deep groundwater in these temporary wells. In wells QRSB-76 and 77, the contact between the oxidized and reduced zone is approximated because of poor sample recovery across the contact zone. This may have placed the water level for these wells very close to or slightly within the oxidized zone. At QRSB-64, although the contact is well identified, the deep well screen is still close (6 in.) to the contact, because the underlying bedrock limited the vertical interval available to be screened. Mixing in this well is supported by some of the measured parameters such as total iron, sulfate, and dissolved oxygen levels, which seem to be more representative of shallow oxidized conditions.

Another possibility for the higher uranium levels at depth in these wells is disequilibrium effects caused by changing water levels (Section 4.1.3). For example, if the water level drops and previously precipitated uraninite is exposed to oxidizing conditions, the uraninite may potentially dissolve (Section 4.5).

4.3 Geochemical Modeling

The U.S. Geological Survey (USGS) geochemical modeling program PHREEQC, Version 2 (Ref. 8), was used to confirm the logic of the observations presented above. PHREEQC is a computer program for simulating chemical reactions in water based on the equilibrium chemistry of aqueous solutions interacting with minerals and a variety of other phases. PHREEQC was used for this study in its basic speciation mode, which calculates the distribution of aqueous species and the saturation state of the solution relative to a set of minerals. Two simulations were run. The oxidized zone was modeled using the water chemistry from sample QRSB-75S, and the reduced zone was modeled using the water chemistry from sample QRSB-73D.

A summary of the pertinent model results is presented in Tables 4-7 and 4-8. The complete model output is included in Appendix D. This discussion focuses on the saturation index (SI), which is a measure of the degree of solution saturation with respect to a given mineral phase. A zero SI indicates equilibrium, a positive SI indicates supersaturation (i.e., the mineral will precipitate), and a negative SI indicates undersaturation (i.e., the mineral will dissolve). Note that the SI is a log scale value.

The QRSB-75S simulation is in good agreement with the other geochemical evidence and interpretations discussed above. SIs for calcium carbonate minerals aragonite and calcite are -0.17 and -0.02, respectively, which is expected of a groundwater in equilibrium with limestone. Quartz is in approximate equilibrium with a SI of 0.42, which is consistent with the presence of abundant clay minerals. Iron oxides goethite and hematite are supersaturated at SIs of 2.87 and 7.70, respectively. The uranium minerals coffinite and uraninite are undersaturated at SIs of –1.61 and –0.95, respectively, which is consistent with the predictions discussed in Section 5.2.1. Uraninite undersaturation is particularly notable here, because QRSB-75S had the highest measured dissolved uranium concentration at 4590 pCi/L.

Table 4-7 Saturation Indices from PHREEQC Simulation of QRSB-75S (Oxidized Zone)

Mineral	Chemical Formula	Saturation Index (SI)
Aragonite	$CaCO_3$	-0.17
Calcite	$CaCO_3$	-0.02
Coffinite	$USiO_4$	-1.61
Goethite	FeOOH	2.87
Hematite	FeS_2	7.70
Quartz	SiO_2	0.42
Uraninite	UO_2	-0.95

The QRSB-73D simulation also supports the geochemical interpretation. SIs for calcium carbonate minerals aragonite and calcite are -0.13 and 0.02, respectively, which is expected of a groundwater in equilibrium with limestone. Quartz is in approximate equilibrium with a SI of 0.7, which is consistent with the presence of abundant clay minerals. Iron oxides goethite and hematite are supersaturated at SIs of 4.34 and 10.65, respectively, and the reduced iron phase pyrite is even more supersaturated at SI of 14.45. The uranium precipitates coffinite and uraninite are supersaturated at SIs of 0.41 and 0.80, respectively, which is consistent with the predictions discussed in Section 4.2.1.

Table 4-8 Saturation Indices from PHREEQC Simulation of QRSB-73D (Reduced Zone)

Mineral	Formula	Saturation Index
Aragonite	$CaCO_3$	-0.13
Calcite	$CaCO_3$	0.02
Coffinite	$USiO_4$	0.41
Goethite	FeOOH	4.34
Hematite	Fe_2O_3	10.65
Pyrite	FeS_2	14.45
Quartz	SiO_2	0.70
Uraninite	UO_2	0.80

The PHREEQC modeling thus provides an independent corroboration of the geochemical interpretation. The modeling results indicate that the shallow aquifer is in equilibrium with limestone and quartz and is under oxidizing conditions where iron and manganese oxides precipitate but uranium is very soluble. Conversely, the deeper aquifer, while still in equilibrium with limestone and quartz, is under reducing conditions in which uranium is insoluble and precipitates as uraninite and coffinite, as do other stable reduced phases such as sulfide minerals.

4.4 Distribution Coefficients

The distribution coefficient (K_d) is a linear coefficient used to characterize the partitioning of ions or molecules between constituents in solution and constituents sorbed by alluvial material. The K_d describes the cumulative effects of all operative sorption processes in a given environment, including adsorption to Fe and Mn oxides, cation exchange with clay and other minerals, and complexation and adsorption by organic matter. The K_d does not include the effects of precipitation of stable species, the formation of which is not directly related to sorption processes.

K_ds for uranium were calculated using the following equation:

$$K_d = C_{sorbed} / C_{aqueous}$$

where C_{sorbed} is the solid phase uranium concentration in soil of the alluvial aquifer, and $C_{aqueous}$ is the dissolved uranium concentration in groundwater. In situ K_ds were determined using the total uranium concentrations from soil samples from the oxidized saturated zone and dissolved uranium samples from groundwater samples collected from the same interval as the soil samples. Data from the reduced zone, where precipitated uranium is present, were not used. Table 4-9 shows the uranium concentrations in soil and groundwater for each sample and the resulting K_d values. Figure 4-13 shows the aerial distribution of the K_d values in the quarry alluvium north of the slough.

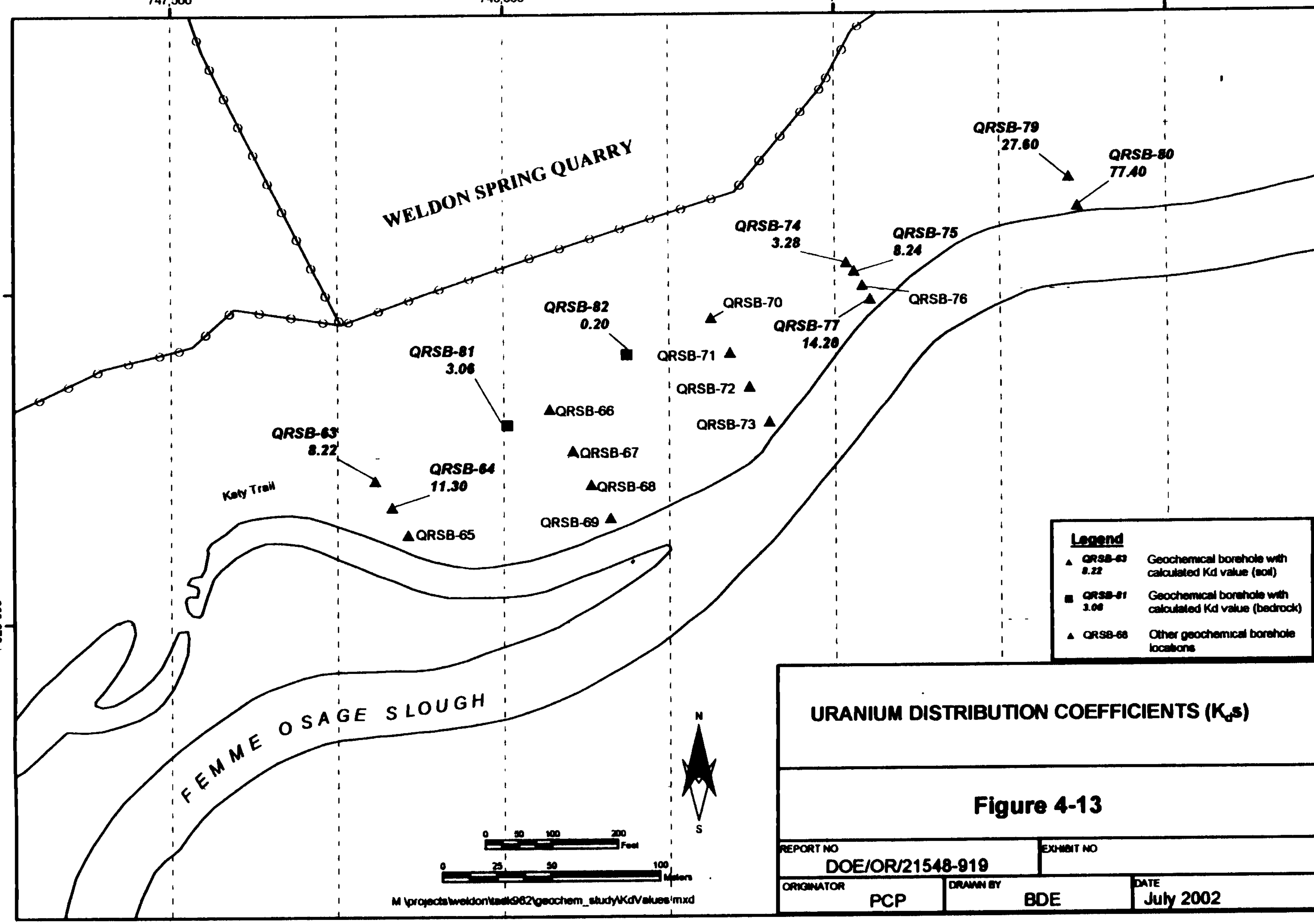
Table 4-9 Summary of Distribution Coefficients

Sample ID	Uranium		K_d (L/kg)
	Soil (pCi/g)	Groundwater (pCi/l)	
QRSB-63S	3.28	399	8.22
QRSB-64S	10.21	902	11.32
QRSB-74S	14.02	4270	3.28
QRSB-75S	37.81	4590	8.24
QRSB-77S	31.03	2180	14.23
QRSB-79S	2.1	76.1	27.60
QRSB-80S	1.64	21.2	77.36
QRSB-81S*	0.82	268	3.06
QRSB-82S*	0.53	2650	0.20

* Bedrock samples.

The distribution coefficient in the bedrock samples was determined from whole rock samples. The calculated K_d values are relatively low (Table 4-9), in part because of the low concentrations of uranium measured in the limestone rock.

The *Sampling Plan* (Ref. 3) identified the correlation of the K_d values with lithologic and chemical properties of the alluvial materials as an area of study. The K_d values and the physical and chemical parameters measured in the same soil samples are given in Table 4-10. As the parameter-specific discussions below explain, there is no strong correlation between K_d and any given parameter, with the exception of a possible correlation with total organic carbon.



URANIUM DISTRIBUTION COEFFICIENTS (K_ds)

Figure 4-13

REPORT NO	EXHIBIT NO	
DOE/OR/21548-919		
ORIGINATOR PCP	DRAWN BY BDE	DATE July 2002

Table 4-10 Comparison of Alluvium K_d Values and Selected Parameters

Sample ID	K_d (L/kg)	USCS Soil Classification[1]	Clay Content (%)	Total Fe (mg/Kg)	Total Mn (mg/Kg)	TOC (mg/Kg)
QRSB-63S	8.22	SC (CH)	18	15600	407	8260
QRSB-64S	11.32	CH	71	26000	344	8110
QRSB-74S	3.28	CH (SM)	63	14600	140	7460
QRSB-75S	8.24	CL (SM)	25	14400	131	6690
QRSB-77S	14.23	CL (CH)	Not tested	13600	305	5530
QRSB-79S	27.60	CL (CH)	32	20400	537	8610
QRSB-80S	77.36	SC	72	15400	500	9270

1 Classifications are based on field descriptions using ASTM 2488. Classification in parentheses denotes secondary soil type.

4.4.1 Grain Size Distribution

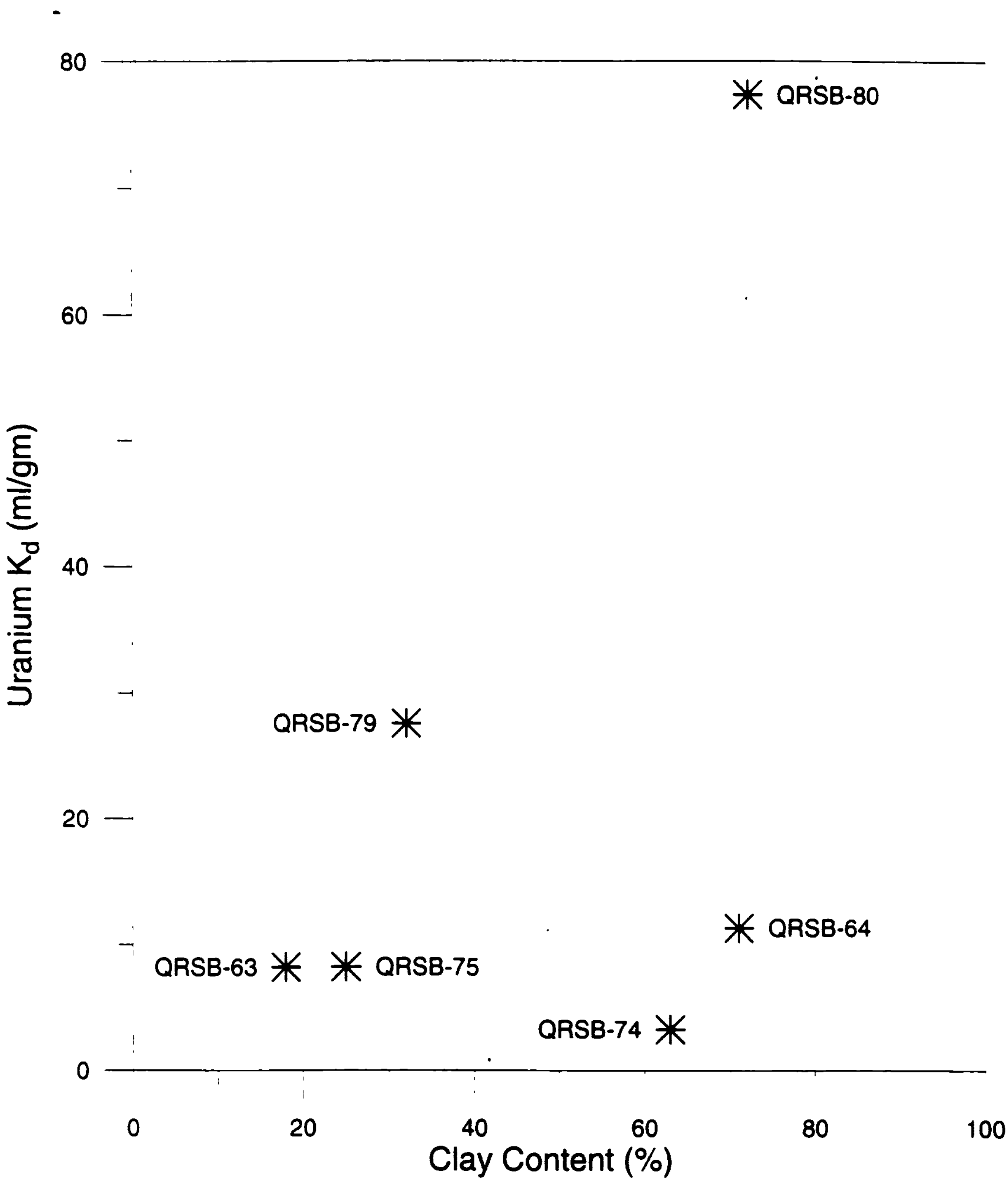
Most of the samples retrieved for K_d analysis were from clays, usually low-to high-plasticity silty clay commonly interbedded with silt or fine sand. Clay percentage and the K_d value for the same sample interval were graphed (Figure 4-14) and show a weak correlation. The highest K_d value was in the sample from QRSB-80S, which also exhibited the highest clay percentage. However, QRSB-64S had similar clay content but a significantly lower K_d.

4.4.2 Iron

Iron oxides are important contributors to the sorptive capacity of soils. Iron oxides are common soil constituents, occurring as coatings on soil particles, fillings in cracks and veins, and as discrete nodules, all of which can accumulate trace elements by coprecipitation, surface complexation, or diffusion. High K_ds can therefore be associated with high concentrations of iron oxides. However, this correlation was not evident in the samples from the alluvium. Total iron and K_d values for each sample were graphed (Figure 4-15), and no correlation was evident. QRSB-80 for example, which had the highest K_d value, did not have the highest concentration of total iron in soil samples.

4.4.3 Manganese

Manganese oxides behave similarly to iron, and can contribute to the sorptive capacity and, hence, the K_d of a soil. In samples from the alluvium north of the slough, an apparent correlation can be seen with manganese content and K_d values (Figure 4-16). However, since manganese values are relatively low (approximately an order of magnitude less than iron or organic carbon), manganese is unlikely to have a significant effect on sorption.



GRAPH OF
Kd vs. CLAY CONTENT IN ALLUVIUM

FIGURE 4-14

DOE/OR/21548-919

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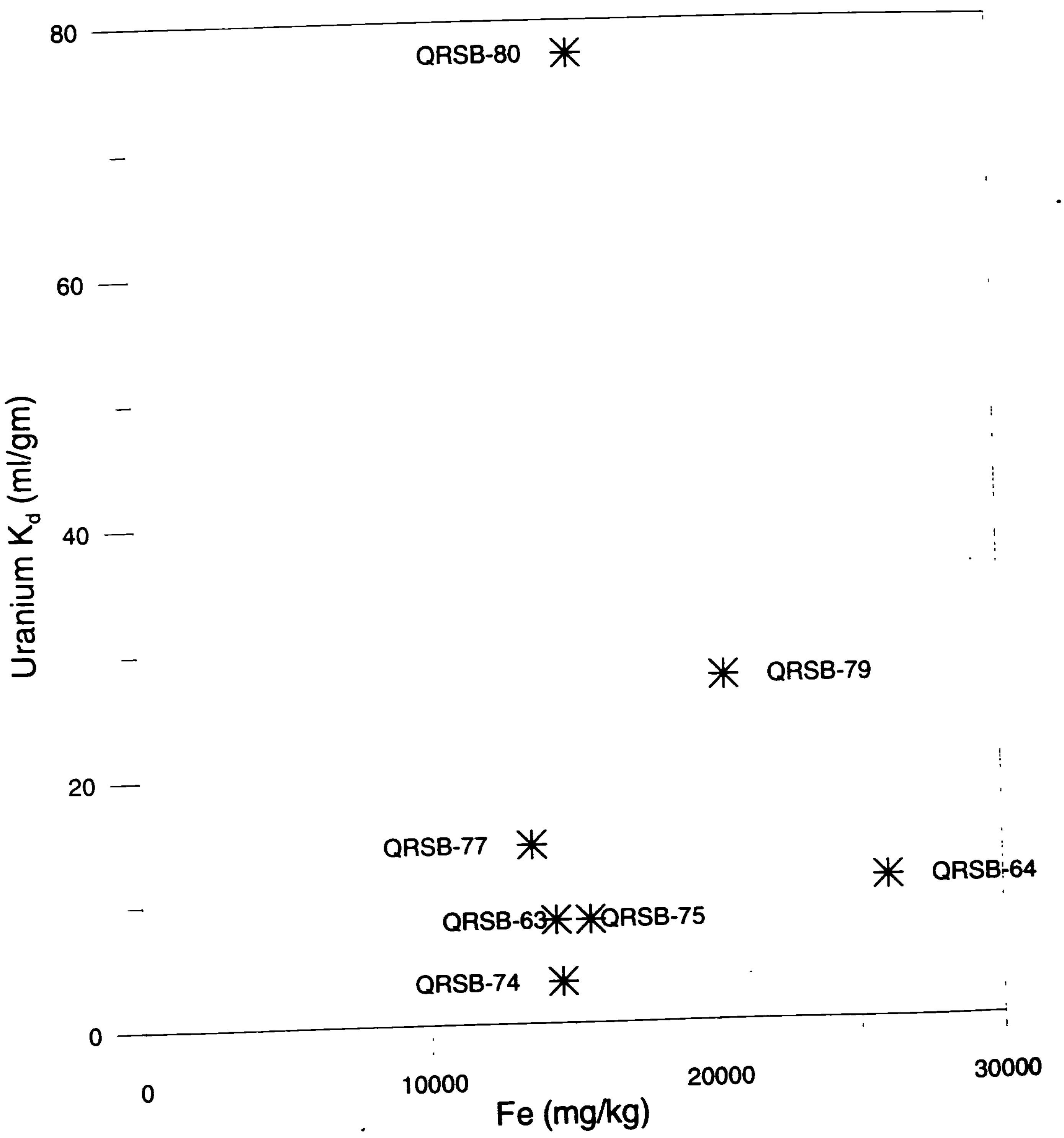
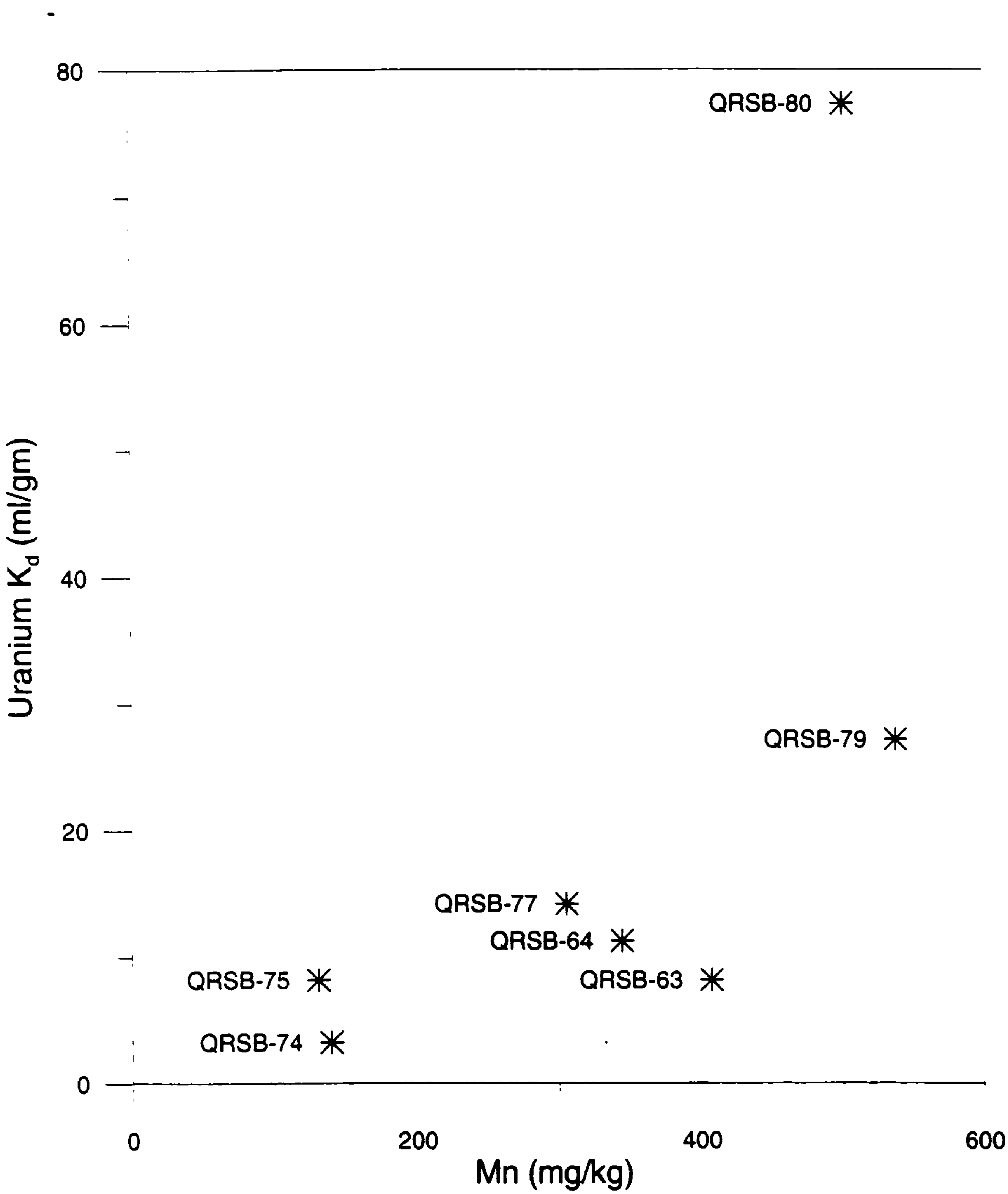


GRAPH OF Kd vs. IRON CONTENT	
FIGURE 4-15	
DOE/OR/21548-919	
	AUGUST 2002



GRAPH OF Kd vs. MANGANESE CONTENT	
FIGURE 4-16	
DOE/OR/21548-919	

4.4.4 Total Organic Carbon

The most noticeable correlation of any parameter is that of total organic carbon (TOC) and K_d. A moderate correlation between high TOC levels in soil and high K_d values can be seen in Figure 4-17. This is significant because of the overall high percentage of organic material in the alluvial sediments, which act as sorption sites.

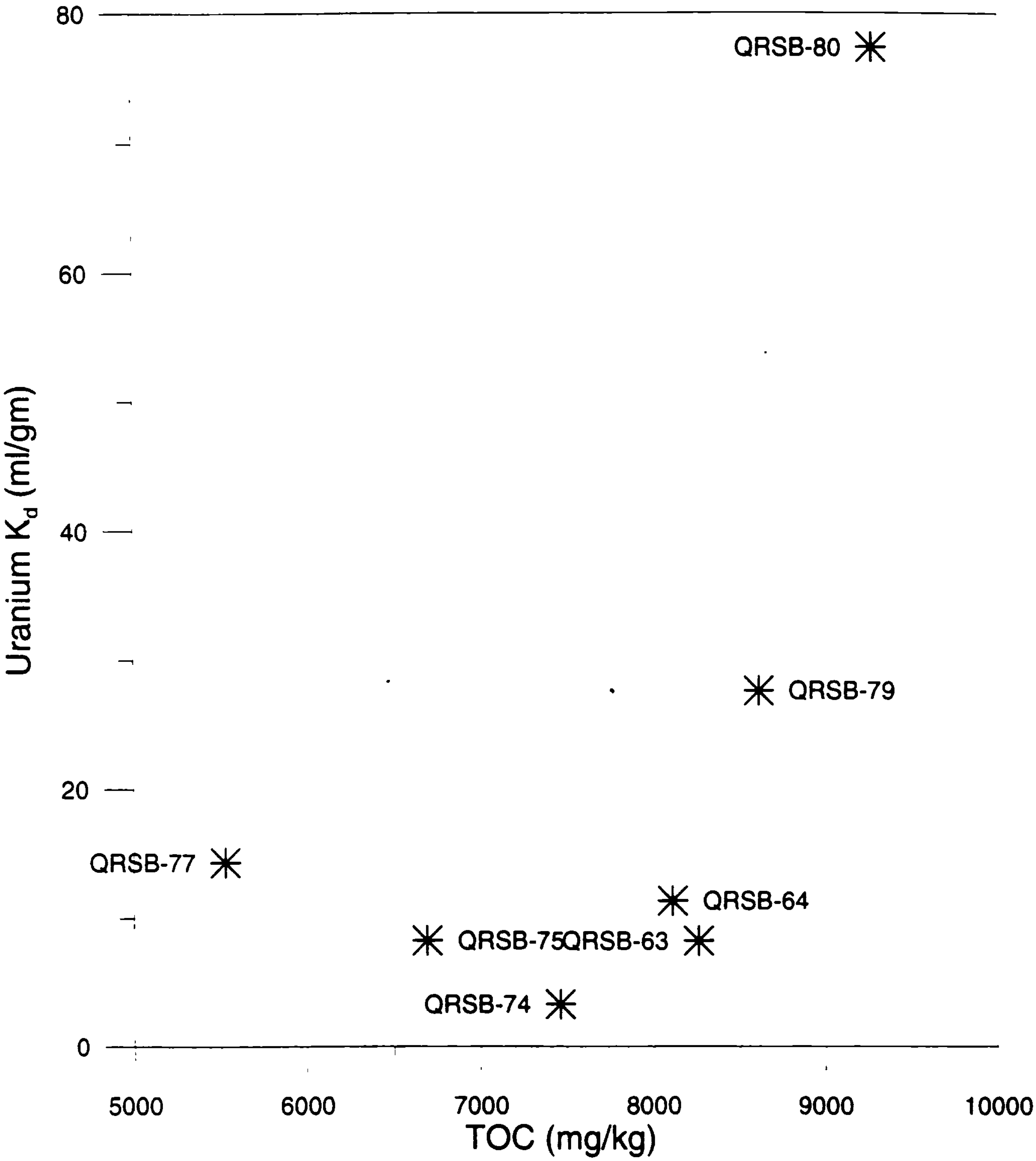
4.5 Uranium Distribution

4.5.1 Uranium Distribution in Groundwater

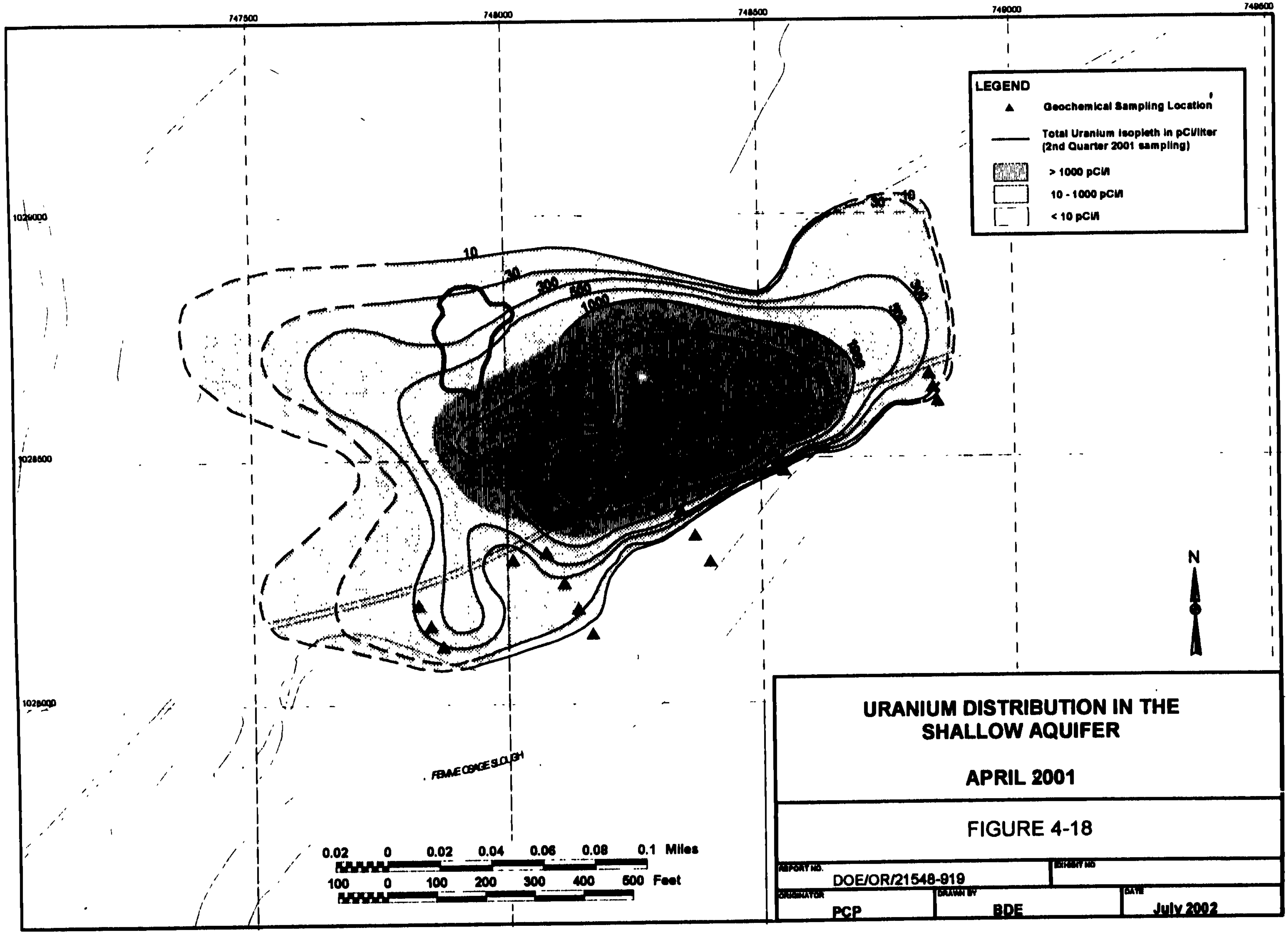
The distribution of dissolved uranium in groundwater within the quarry area during April 2001 is presented in Figure 4-18. This dissolved plume reflects an environment where the chemical reduction zone in the alluvium exerts an immediate effect on the uranium distribution by rapidly causing uranium to precipitate out of solution over a very short distance. This is evidenced on the plume map, which shows uranium concentrations dropping from 2,500 pCi/L to less than 10 pCi/L within a distance of less than 100 ft.

Fluctuating water levels can potentially cause the location of the oxidized/reduced zones to vary resulting in a short-term variation in uranium transport processes within a localized area. Changes in oxidation/reduction state as water levels rise, could result in resaturation of sediments in the unsaturated zone containing sorbed uranium that might result in desorption of uranium. The extent of desorption will depend on the concentration of dissolved uranium in the water, with desorption occurring only until equilibrium is reached. This pattern, an increase in uranium concentrations in groundwater as water levels rise, has been observed in monitoring wells located midway between the Katy Trial and the slough (Ref. 5). Monitoring wells located adjacent to the slough that typically exhibit reducing chemistry do not exhibit changes in uranium concentration with changing water levels.

Another potential effect of the fluctuating water level is that with higher water levels, more oxygenated water from precipitation or recharge from the Missouri River enters the area north of the slough. The effect of the increasing water level is an increase the Eh and dissolved oxygen content causing changes to the precipitation/dissolution reactions of uranium locally, as well as all other redox-sensitive species (Ref. 5). As water levels rise, dissolution of previous precipitated uraninite and other reduced species occurs in a localized area. Again, the monitoring wells located adjacent to the slough do not exhibit changes in uranium concentration with changing water levels.



GRAPH OF Kd vs. TOTAL ORGANIC CARBON CONTENT	
FIGURE 4-17	
DOE/OR/21548-919	
	AUGUST 2002



URANIUM DISTRIBUTION IN THE SHALLOW AQUIFER

APRIL 2001

FIGURE 4-18

4.5.2 Uranium Distribution in Soil

Soil samples were collected for uranium analysis as part of this characterization to determine K_ds and geochemical controls on uranium sorption and precipitation. Table 4-11 presents all of the uranium results for alluvial soil samples. Analytical data for soil is presented in Appendix B. Total uranium concentrations in soil range from 1.05 pCi/g in the deep sample collected from QRSB-65D up to 177.7 pCi/g in a discrete sample taken from QRSB-77D.

Table 4-11 Uranium Concentrations in Soil

Location	Sample Interval (ft BGS)	U-234 (pCi/g)	U-235 (pCi/g)	U-238 (pCi/g)	Total Uranium (pCi/g)
QRSB-63S	9.6 – 11.8	1.50	0.08	1.70	3.28
QRSB-64S	12.0 – 14.0	5.20	0.31	4.70	10.21
QRSB-64D	15.2 – 16.8	2.52	0.13	2.65	5.30
QRSB-65S	11.2 – 13.4	0.92	< 0.065	0.99	1.91
QRSB-65D	20.0 – 22.0	0.53	< 0.12	0.52	1.05
QRSB-66S	9.5 – 11.5	3.76	0.11	3.81	7.68
QRSB-67S	10.0 – 12.0	11.10	0.95	10.70	22.75
QRSB-67D	14.5 – 17.5	0.60	[0.04]	0.31	0.91
QRSB-68S	6.5 – 8.5	9.20	0.64	10.00	19.84
QRSB-68D	14.4 - 16.4	0.56	0.06	0.78	1.40
QRSB-69S	4.7 - 6.5	4.12	0.17	4.11	8.40
QRSB-69D	13.0 - 14.5	0.50	[0.04]	0.65	1.15
QRSB-70S	9.2 - 11.2	4.90	0.28	5.00	10.18
QRSB-71S	8.9 - 10.1	35.20	1.98	35.00	72.18
QRSB-71D	13.2 -15.0	0.51	[0.03]	0.65	1.16
QRSB-72S	8.0 - 9.2	14.70	0.76	14.60	30.06
QRSB-72D	13.2 - 18.0	0.68	[0.02]	0.61	1.29
QRSB-73S	8.2 - 9.6	4.90	0.22	5.70	10.82
QRSB-73D	13.0 - 16.6	0.71	[0.03]	0.59	1.30
QRSB-74S	9.0 - 12.0	7.00	0.32	6.70	14.02
QRSB-75S	8.0 - 12.5	18.10	0.81	18.90	37.81
QRSB-75S(1)	12.0 – 12.2	10.20	0.59	10.30	21.09
QRSB-76S	5.4 - 6.6	17.20	1.06	17.40	35.66
QRSB-76D	8.0 - 12.0	2.34	0.10	2.56	5.00
QRSB-77S	5.0 - 7.0	14.90	0.83	15.30	31.03
QRSB-77D	8.0 - 13.0	1.35	1.25	1.35	3.95
QRSB-77D(5)	8.0 - 8.2	87.00	4.70	86.00	177.70
QRSB-77D(1)	8.2 - 9.0	1.25	[0.13]	1.09	2.34
QRSB-77D(2)	9.0 - 10.0	0.80	[0.02]	0.81	1.61
QRSB-77D(3)	10.0 - 11.0	0.52	< 0.17	0.70	1.22
QRSB-77D(4)	11.0 - 12.0	0.88	[0.12]	0.73	1.61
QRSB-79S	9.4 - 11.4	1.08	[0.03]	0.99	2.07
QRSB-80S	8.6 - 11.5	0.76	> 0.01	0.88	1.64
QRSB-80D	13.0 - 15.0	0.79	[0.06]	1.06	1.85

[###] = Estimated value below the detection limit

The scope of this study included finding a borehole location with a well-defined oxidized/reduced zone contact and studying the uranium distribution in the soil right at and immediately beneath the contact and further into the reduced zone. The goal of this sampling was to determine how the uranium precipitates across the contact.

During meter surveying of the soil core from QRSB-77D for waste disposal purposes, a zone exhibiting elevated instrument reading (11,200 disintegrations per minute) was identified in the 8 to 8.2 ft interval of the core. This interval was just beneath the approximate oxidized/reduced contact for the borehole, selected at 7.5 ft. Because the soil exhibiting higher activity was close to the contact, additional sampling was performed to determine vertical variability in uranium concentrations in soil at the contact. The results for these samples are given in Table 4-11.

The relatively high concentration of uranium in soil immediately below the contact is worth noting. The next sample below contains almost no uranium as with the rest of the samples, which were collected as 1 ft samples progressing downward from the contact. This sampling demonstrates that, at this location, the reduction/precipitation reaction was rapid, depositing the majority of the precipitated uranium in the first few inches below the contact.

5. QUALITY CONTROL

Data evaluation was performed on the analytical data generated from this field study to determine whether Weldon Spring Site Remedial Action Project (WSSRAP) data quality objectives were met and to ensure that quality results were generated. Data evaluation was performed in accordance with the *Environmental Quality Assurance Project Plan* (EQAPjP) (Ref. 4). The data evaluation process was completed through data verification, data review, data validation, and data management.

5.1 Data Evaluation

Data verification was conducted in accordance with procedure ES&H 4.9.1, *Environmental Monitoring Data Verification*, to ensure that documentation and data were reported in compliance with established reporting requirements and standard operating procedures and that all analyses were performed. Analytical results received from the laboratory were reviewed to verify that samples were properly handled according to WSSRAP protocol. The following factors were reviewed and evaluated: sample identification, chain-of-custody, holding times, sample preservation requirements, sample analysis request forms, laboratory tracking, data reporting requirements, and database transfer.

Data packages were reviewed to ensure that the final data were properly identified, analyzed, reported, and met data quality requirements. The data were also reviewed to check for inconsistencies with the field quality control samples. Final analytical results were compared to the preliminary analytical results to identify any changes in data.

5.2 Quality Control Analyses

The *Sampling Plan* (Ref. 3) indicated that quality control samples would be taken at a frequency of 1 per 20 samples or 5%. Quality control samples included matrix duplicates (DU), field replicates (FR), and matrix spike/matrix spike duplicates (MS/MSD). Although the quality analyses were not run on separate samples, the quality control sample frequency requirement (5%) was satisfied. Quality control data are provided in Appendix C.

Matrix duplicate samples are aliquots taken from the parent sample at the laboratory. Field replicates are split from the parent sample in the field and submitted to the same laboratory as the parent sample. The matrix duplicate and field replicate results are compared to the parent sample and the relative percent difference (RPD) is calculated for each. The recommended RPD for radiological and chemical parameters is less than or equal to 50% and 35%, respectively. RPDs are not calculated for "non-detect" results. Also, if one or both of the results are less than five times the detection limit, the RPD value is considered of limited value due to higher tolerance limits near the analytical detection limit.

Fifty-four DUs or FRs were analyzed for this study. The RPD values ranged from 0% to 91%. Replication of manganese values for two soils samples (SO-100017-S and SO-100018-S) was greater than the recommended 35% limit for chemical parameters. The high RPD values are likely the result of the natural variation of manganese in the soil samples. A summary of the quality control analyses is provided in Appendix C.

Matrix spikes are sample aliquots split by the laboratory that are treated in the same manner as the parent samples with the exception that these samples have been spiked with a known amount of the target analytes to determine the precision of the method in a given sample type or matrix. The samples are processed as regular samples and a percent recovery is determined after analysis. Matrix spike duplicates are split samples of the matrix spikes that are treated in the same manner as the matrix spike parent samples. A percent recovery is determined after the analysis, as well as the RPD between the MS and MSD. The recommended percent recovery is +/- 20% for radiological and nitroaromatic compound parameters.

Thirty-three MS/MSDs were analyzed for this study. The percent recovery values for the soil samples (SO-100017-S and SO-100018-S) were outside the acceptable range. The RPDs were typically within the acceptable ranges for uranium compounds. The variation in the percent recovery values is likely the result of inherent heterogeneity within the soil matrix.

5.3 Equipment Blanks

Although not included in the *Sampling Plan* (Ref. 3), one equipment blank sample was collected by pouring deionized water over a washed CME continuous sample barrel and collecting the water in sample bottles. Results showed some detects of analytes but no concentrations that would require an adjustment to the soil sampling results. Complete equipment blank analytical results are included in Appendix C.

5.4 Field Quality Control Procedures

The Hach DR-2000 analyzer was calibrated using the manufacturer's standards and methods for sulfide and ferrous iron before performing field analysis. The Horiba U10 water quality checker was calibrated daily according to manufacturer's recommendations before each use in the field.

6. SUMMARY AND CONCLUSIONS

6.1 Summary

Drilling, temporary well installation, and groundwater testing were conducted in the area of uranium impact north of the Femme Osage slough from October 25, 2001 through November 21, 2001. Soil sampling was conducted at 17 borehole locations, and 21 temporary wells were installed, tested, and sampled during that period. Drilling and testing were performed to meet the following objectives:

- Evaluate the groundwater geochemistry north of the Femme Osage Slough, emphasizing factors that influence the attenuation of uranium in groundwater.
- Estimate the uranium distribution coefficients (K_ds) for the alluvial and bedrock aquifer materials north of the slough.
- Characterize the oxidation state of groundwater throughout the alluvial aquifer and define the boundary of the reducing zone north of the slough.
- Determine the distribution of precipitated uranium across the reducing front.

This study achieved the objective of determining and quantifying the mechanisms attenuating uranium in the groundwater north of the slough. Oxidation state and redox-sensitive parameter data clearly defined the oxidizing and reducing zones of the alluvial aquifer and the boundary between them. Distribution coefficients were determined from depth-discrete sampling data to determine the sorption/desorption capacity of the aquifer matrix. The distribution of uranium in soil across the reducing front was quantified where uranium was concentrated in a narrow band beneath the oxidized/reduced contact.

6.2 Conclusions

The results of the geochemical characterization have provided a better understanding of the natural geochemistry of the alluvial aquifer north of the Femme Osage slough and its impact on the fate of uranium contamination in groundwater. This area contains a naturally occurring oxidation/reduction front, which acts as a barrier to the migration of dissolved uranium by inducing its precipitation. These results confirm that the geochemical parameters measured in the field and laboratory support observations and interpretations made during previous investigations. The physical and chemical parameters measured in groundwater samples were successfully correlated with the physical properties of the aquifer material and support the conceptual fate and transport model presented in the *Remedial Investigation* (Ref. 9).

6.2.1 Oxidizing and Reducing Zones

A distinct contact was evident across the study area separating alluvial soils with characteristics indicative of oxidized conditions from those indicating reducing conditions. This oxidized/reduced zone contact was also documented during earlier studies (Ref. 2), and those observations remain consistent with those of this fieldwork. The oxidized/reduced zone contact is characterized as a change in the physical characteristics of the alluvial material with depth, most obviously in the form of a color change from primarily yellow/browns to gray/blacks. Other indicators are the presence or absence of iron oxides such as limonite and hematite in the oxidized zone and carbonized or coalified organic material in the reduced zone.

The geochemical sampling program was designed to obtain soil and groundwater samples from discrete intervals from both the oxidized and reduced zones. Field parameters (pH, Eh, conductivity, dissolved oxygen, turbidity, and temperature) and redox-sensitive parameters (ferrous iron [Fe^{2+}] and sulfide [S^{2-}]) were measured in all groundwater samples at the wellhead. This field-testing was necessary to assure accurate measurement of redox-sensitive parameters that could be oxidized during a delayed laboratory analysis. Field analyses also allowed an immediate confirmation of the visual distinction of oxidizing versus reducing conditions.

Discrete groundwater samples were collected from wells that were screened to isolate zones above and below the redox front. Analytical results for redox parameters, including Eh, dissolved ferric/ferrous iron, manganese, sulfate/sulfide, and uranium were consistent with field observations distinguishing the oxidizing and reducing zones. The only exception was dissolved oxygen results, which were inconsistent due to oxidation during analysis.

6.2.2 Uranium Distribution Control

This study confirms that the primary mechanisms controlling the distribution of uranium in groundwater in the quarry area are precipitation due to the presence of an oxidation-reduction front and the sorption in the aquifer materials north of the slough. Samples were collected to determine the distribution coefficient (K_d) for the alluvium and bedrock in the quarry area. A correlation of the K_d values with lithologic and chemical properties of the alluvial materials indicates the strongest correlation is with total organic carbon content.

The distribution of dissolved uranium in groundwater reflects an environment where the chemically reducing portion of the alluvial aquifer exerts an immediate effect on the distribution by rapidly causing uranium to precipitate out of solution over a very short distance. Fluctuating water levels may cause localized short-term variation in uranium transport resulting from a local change in precipitation/dissolution reactions of uranium, as well as sorption/desorption processes. The rapid change in uranium soil concentrations at the oxidation/reduction contact supports the dramatic decrease in uranium groundwater concentrations within a distance of less than 100 ft. Although uranium groundwater concentrations levels may fluctuate locally due to several factors, overall the areal extent of uranium impact is controlled by precipitation of uranium due to changes in oxidation/reduction state.

Evidence for the rapid precipitation of uranium from groundwater was also observed in soil samples from QRSB-77D, which indicated a thin zone exhibiting elevated scintillation

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PROCEDURES

ES&H 4.1.2	*Initiation, Generation, and Transfer of Environmental Chain-of-Custody.*
ES&H 4.4.1	*Groundwater Sampling*
ES&H 4.4.7	*Soil, Rock Core, and Rock Chip Borehole Logging*
ES&H 4.9.1	*Environmental Monitoring Data Verification*

Appendix A
Borehole Logs/Well Diagrams

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

TEMPWLOG

HOLE NUMBER	QRSB-63
SHEET 1 OF 1	
NORTH (Y):	1028216
EAST (X):	747807
TOC ELEVATION	461.8
GROUND ELEVATION	459.8
STICKUP	2.0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

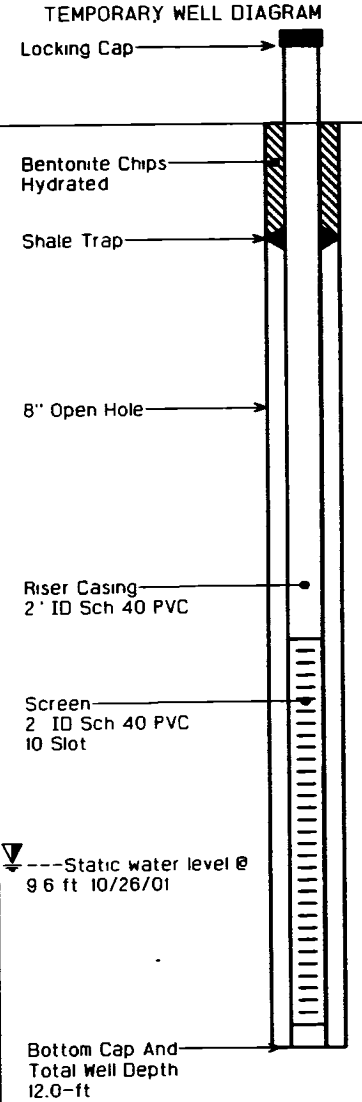
WELL STATUS/COMMENTS	TEMPORARY WELL
LOCATION	QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR	GEOTECHNOLOGY INC
DRILL RIG MAKE & MODEL	CME-550
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
DATE START	10/26/01
DATE FINISH	10/26/01
DEPTH (FT.) FROM / GROUND ELEV TO: BOTTOM OF HOLE (TD)	12.0
BEDROCK	~11.8
WATER LEVELS & DATES	▽ ▼

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
0.0–0.7	GP-1	45/47"		TOP SOIL	0.0'-0.7' CLAY, with silt and sand, roots, very dark gray CL Topsoil	MO. R. ALLUV.
0.7–1.5				CL	0.7'-1.5' SILTY CLAY, ~30% silt, low plasticity, some organics, dark grayish brown (10YR4/2), firm (pp=1.5) CL	
1.5–3.6					1.5'-3.6' CLAY, low to med. plasticity, some roots, minor FeOx, grayish brown (10YR5/2), damp, hard (pp=2.25) CL	
3.6–4.0				ML	3.6'-4.0' SILT, some clay, FeOx, grayish brown, soft ML	
4.0–4.6	GP-2	48/48"		CH	4.0'-4.6' CLAY, med. to high plasticity, blocky texture, abundant roots replaced with FeOx (orange), very dark grayish brown (10YR3/2), dry to damp CH	
4.6–7.0				CL	4.6'-7.0' SILTY SANDY CLAY, ~15% silt, ~10% very fine sand, low plasticity, abundant FeOx roots as above, dark grayish brown (10YR4/2), damp CL	
7.0–7.4				SC	7.0'-7.4' CLAYEY SAND, very fine-grained, abundant FeOx, dark grayish brown (10YR4/2), damp SC	
7.4–10.1	GP-3	43/46"		CH	7.4'-10.1' CLAY, med. to high plasticity, blocky texture, abundant FeOx roots, dark grayish brown (10YR4/2), damp to moist, hard (pp=2.75) CH	
10.1–11.8				SC	10.1'-11.8' CLAYEY SAND, very fine-grained, clay varies from ~10 to 50%, minor silt, sandy clay lenses between 10.8' and 11.2', FeOx blebs throughout, grayish brown (2.5Y5/2), moist to very moist, loose to med. dense SC	
					Sampler refusal at 11.8', total drilled depth 12.0'. Installed a temporary 2" diameter PVC monitoring well	

Depth scale (feet): 5, 10, 15. Elevation scale (feet): 455, 450, 445.

TEMPORARY WELL DIAGRAM



Sample Interval ☐ No Sample Taken ▽ minimum ▼ maximum ▼ average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-64
SHEET 1 OF 1	
NORTH (Y):	1028176
EAST (X):	747832
TOC ELEVATION	-
GROUND ELEVATION	458 9
STICKUP	-
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS: CHARACTERIZATION BOREHOLE	LOCATION: QUARRY INTERCEPTOR TRENCH
DRILLING CONTRACTOR: GEOTECHNOLOGY, INC	DRILL RIG MAKE & MODEL: CME-550 ATV
HOLE SIZE & METHOD: 7-1/4" HSA, 3" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90
DRILL FLUIDS & ADDITIVES: NONE	CASING TYPE, DEPTH, SIZE: NONE
DATE START: 10-26-01	DATE FINISH: 10-26-01

DEPTH (FT) FROM GROUND ELEV TO: BOTTOM OF HOLE (TD): 17 5; BEDROCK: UNKNOWN; WATER LEVELS & DATES: ▽ ▼

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT	LABORATORY SAMPLES	ELEVATION feet
	GP-1	41/47"	TOP SOIL	0 0'-1 0' CLAY, low plasticity, some silt, very dark grayish brown (10YR3/2), damp CL Topsoil	NO. R. ALLUV.		
			CH	1 0'-2 6' CLAY, silty, med to high plasticity, with roots, some FeOx, dark grayish brown (10YR4/2), moist, hard (pp=3 5) CH			
			CL	2 6'-3 9' SILTY CLAY, ~25% silt, low plasticity, with roots, some FeOx specks, dark grayish brown (10YR4/2), damp CL			
	GP-2	43/48"	CH	3 9'-4 8' CLAY, med to high plasticity, some silt, increase in FeOx blebs (orange), blocky texture, dark grayish brown (10YR4/2), damp, hard (pp=3 75) CH			455
5			CL	4 8'-8 4' SILTY CLAY, low plasticity, ~40% silt as interbeds and mixed with clay, some very fine sand abundant FeOx blebs, grayish brown (10YR5/2), damp CL At 8 4'-8 5', fine to very fine-grained sand lense Above background scintillometer reading			
	GP-3	42/48"		8 5'-10 2' SILTY CLAY, ~10-15% silt, med plasticity, increasing with depth, dark grayish brown (10YR4/2) with reddish orange FeOx root replacement, damp, hard (pp=3 25) CL			450
10			CH	10 2'-14 9' CLAY, high plasticity, little to no silt, FeOx blebs, dark grayish brown (2 5Y4/2), moist, soft (pp=1 0) CH Oxidized/ reduced contact at 14 9'		----Water level in QRSB-64S @10 7 ft	
	GP-4	40/48"				----Water level in QRSB-64D @12 4 ft Sample SO-100002A	445
15	GP-5	9/18"		14 9'-16 5' CLAY, very high plasticity, some silt, some sandy interbeds, no FeOx, pulls like taffy, dark gray (5Y4/1), moist, very soft (pp=< 25) CH		Sample SO-100002B	
			SM SC	16 5'-17 5' SILTY SAND, fine-grained, some clay, dark gray (5Y4/1), WET, loose to med dense SM/SC Poor sample recovery			
				Sampler refusal at 17 5' Installed 2 temporary PVC monitoring wells for oxidized and reduced water conditions		Installed paired temporary wells screened as follows QRSB-64S 9-14 ft QRSB-64D 15 5-17 ft	440
20				The oxidized/reduced contact is picked at 14 9 ft			

■ Sample Interval ☐ No Sample Taken ▽ minimum ▼ maximum ▼ average

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-65
SHEET 1 OF 1	
NORTH (Y):	1028134
EAST (X):	747856
TOC ELEVATION	
GROUND ELEVATION	457.7
STICKUP	
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS	CHARACTERIZATION BOREHOLE
LOCATION	QUARRY INTERCEPTOR TRENCH
DRILLING CONTRACTOR	GEOTECHNOLOGY, INC
DRILL RIG MAKE & MODEL	CME-550 ATV
HOLE SIZE & METHOD	7-1/4" HSA, 3" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
DRILL FLUIDS & ADDITIVES	NONE
CASING TYPE, DEPTH, SIZE	
DATE START	10-24-01
DATE FINISH	11-5-01
DEPTH (FT.) FROM GROUND ELEV. TO: BOTTOM OF HOLE (TD)	26 5
BEDROCK	UNKNOWN
WATER LEVELS & DATES	

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
	GP-1	35/47"		Top soil	Topsoil	NO. R. ALLUV.		
				CL	1 0'-4.0' CLAY, silty, silt varies up to 50%, FeOx mottling, dark grayish brown (10YR4/2), moist, hard (pp=2 75) CL			455
5	GP-2	46/48"		CL/ML	4 0'-8 5' SILT, clayey, abundant organics, silty clay interbeds up to 2 , FeOx mottling, dark grayish brown 10YR4/2) and strong brown (7.5YR5/6), moist, very soft (pp=< 25) ML			450
10	GP-3	37/48"		CL	8 5'-11 2' CLAY, silty, ~30%, with ~10-20% very fine sand, medium to non plastic and in silty pockets, abundant oxidized rootlets, grayish brown (2 5Y5/2), moist, soft (pp= 5). CL		---Water level in QRSB-65S @9 8 ft	
	GP-4	28/48"		CH	11 2'-13 4' CLAY, high plasticity, dark grayish brown (2.5Y4/2) with FeOx mottling, damp to moist, firm (pp=1 5) CH		Soil Sample SO-100003A	445
15					13 4'-17 0' CLAY, very high plasticity, putty-like, no FeOx, dark gray, very moist, WET at 16', very soft (pp=< 25) CH		---Water level in QRSB-65D @14 2 ft	
	GP-5	30/48"		ML/CL	17 0'=18 5' SANDY SILT AND CLAY, interbedded, other as above 18 5'-19 5' No recovery			440
20	GT-6	26/48"		CH	19 5'-22 0' SANDY SILT AND SAND, with interbedded clay, high plasticity, CH, other as above		Soil Sample SO-100003B	
25	GT-7	28/30"		SC	22.0'-26 5' SAND, fine to very fine-grained, poorly graded, ~20% clay, SC, other as above Sampler refusal at 26 5-ft.		Installed paired temporary wells screened as follows: QRSB-65S 7.8-12 8 ft QRSB-65D 19-24 ft.	435
					Total depth 26 5' Oxidized/reduced contact at approximately 13 4 ft			430
30								425
35								

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

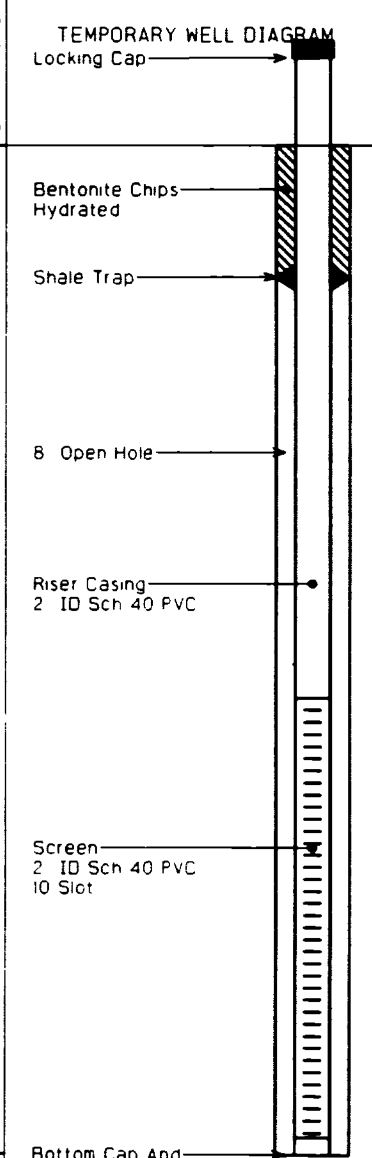
BOREHOLE AND WELL COMPLETION LOG

HOLE NUMBER: QRSB-66	SHEET 1 OF 1	NORTH (Y): 1028324	EAST (X): 748069
WELL STATUS/COMMENTS: TEMPORARY WELL	LOCATION: QUARRY INTERCEPTOR TRENCH AREA	TOC ELEVATION:	
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-550	GROUND ELEVATION: 459 0	
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	BOTTOM OF HOLE (TD): 11 5	
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: 11 5	STICKUP:
DATE START: 10/31/01	DATE FINISH: 10/31/01	WATER LEVELS & DATES:	HYDR CONDUCTIVITY (cm/sec): K= NOT DETERMINED

TEMPNLOG

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT
0	CME-1	24/41"	FILL	SILT AND CLAY with limestone gravel up to 2 Fill	MO. R. ALLUV.
3.5	CME-2	10/60"	?	3 5'-8 5' Recovered only 6 CME sampler likely blocked off by fill gravel Soil type unknown	
8.5	CME-3	33/36"	CL SP	8 5'-9 5' CLAY, silty, low plasticity, ~15% silt and ~10% sand, with oxidized roots, very dark grayish brown (10YR3/2), moist, firm CL	
				9 5'-10 5' SAND, fine, poorly graded, subrounded, ~15% silt with ~1/2' thick clayey zones, brown (10YR5/3), moist, med dense SP	
				10 0'-10 4' CLAY, sandy, silty, increased FeOx root replacement, heavy FeOx layer at 10 4', other as above CL	
				10 4'-10 9' SAND as at 9 5', with more FeOx staining, clay-rich interbedding (~1/2') SP	
				10 9'-11 2' CLAY, silty, med plasticity, some sand, abundant oxidized organics, dark grayish brown (10YR4/2), very moist CL	
				11 2'-11 5' SAND as at 10 4' with clay-rich layers, SP and CLAY as at 10 9', CL	
				Total depth at 11 5', sampler refusal Installed a temporary 2 diameter PVC monitoring well	
				*Entire drilled/sampled interval is oxidizing	



Note No groundwater inflow into the temporary well
Remained dry until abandonment

ELEVATION feet: 455, 450, 445

Sample Interval · No Sample Taken · minimum · maximum · average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-67
SHEET 1 OF 1	
NORTH (Y):	1028261
EAST (X):	748105
TOC ELEVATION	460.0
GROUND ELEVATION	458.0
STICKUP	2.0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS: TEMPORARY WELL	LOCATION: QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR: GEOTECHNOLOGY INC	DRILL RIG MAKE & MODEL: CME-550
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A
DATE START: 10/31/01	DATE FINISH: 11/1/01

DEPTH (FT) FROM GROUND ELEV TO: BOTTOM OF HOLE (TD) 22.5; BEDROCK NOT ENCOUNTERED; WATER LEVELS & DATES

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
	CME-1	29/29"	FILL	GRAVEL, limestone with some clay. Fill			
	CME-2	54/60"					455
5			CL	3 6'-5.6' CLAY, low plasticity, ~20% silt, abundant roots, some black organics, some lighter colored interbeds with FeOx, very dark gray (2 5Y3/1), moist, firm (pp=2 0) CL			
	CME-3	54/60"		5 6'-9 4'. CLAY, ~15% silt, ~20% fine sand, increased FeOx as organics replacement, MnOx coating fractures, minor sandy interbeds up to 1", dark grayish brown (10YR4/2), moist to very moist CL		No water in QRSB-67S	450
10				9.4'-12 5' CLAY, low to med plasticity, ~30% silt, ~10% sand to 12', then ~25%, abundant FeOx, moist to very moist, very soft (pp=<.25) CL	MO. R. ALLUV.	Soil Sample SO-100005S	
	CME-4	57/60"		12 5'-13 6'. CLAY, silty, as above No FeOx, some sand stringers, very moist, soft (pp=1 0) CL Oxidized/Reduced contact at 12 7-ft			445
			SC	13 6'-14 0' CLAYEY SAND, fine-grained, ~20% clay and silt, few to no organics, dark gray (5Y4/1), WET, med dense SC		Water Level in QRSB-67D @14 5 ft	
15			CL SC	14 0'-15 2' SANDY CLAY, low plasticity, ~30% sand, abundant organics partly to completely coalified, dark gray, wet, very soft CL		Soil Sample SO-100005D	
				15 2'-15 4' LIGNITE, layered in sheets, possibly originally leaves, black (N2 5), soft, hydrogen sulfide odor			
	CME-5	59/60"	CH	15 4'-15 8' CLAY, silty and sandy as before, abundant organics as coalified wood CL			440
				15 8'-16 0'. SAND, clayey as before, wet SC.			
20			SP	16 0'-18 0' SANDY SILTY CLAY and CLAYEY SAND, interbedded, ~1-3" thick alternating beds, abundant coalified organics CL/SC		Installed paired temporary wells screened as follows: QRSB-67S 7.6-12 6 ft QRSB-67D 14 5-17 5 ft	
				18 0'-20.0' CLAY, very high plasticity, ~10% sand as sand pockets up to 1-1/2", very dark gray (5Y3/1), very soft to soft (pp=<.25-1 0). CH			
				22 0'-22 5' SAND, fine, poorly graded, abundant black organic specks, very dark gray, med dense to loose SP Bottom foot silty			435
				Total depth 22 5' Oxidizing/reducing contact at approximately 12 7 ft			
25							

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

TEMPWLOG

HOLE NUMBER QRSB-68	**SHEET** 1 OF 1	**NORTH (Y):** 1028210
WELL STATUS/COMMENTS TEMPORARY MONITORING WELL	**LOCATION** QUARRY INTERCEPTOR TRENCH AREA	**EAST (X):** 748131.7
DRILLING CONTRACTOR GEOTECHNOLOGY INC.	**DRILL RIG MAKE & MODEL** CME-550	**TOC ELEVATION** 458.1
HOLE SIZE & METHOD 7-1/4" HSA, 4" CME Sampler	**ANGLE FROM HORIZONTAL & BEARING** 90	**BOTTOM OF HOLE (TD)** 18.0
GROUND ELEVATION 456.1		
DRILL FLUIDS & ADDITIVES None	**CASING TYPE, DEPTH, SIZE** N/A	**BEDROCK** NOT ENCOUNTERED
STICKUP 2.0		
DATE START 11/1/01	**DATE FINISH** 11/1/01	**WATER LEVELS & DATES**
HYDR CONDUCTIVITY (cm/sec) K= NOT DETERMINED		

DEPTH (FT.) FROM: GROUND ELEV TO:

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT
0	CME-1	26/35"		TOP SOIL	TOPSOIL	NO. R. ALLUV.
				CL	0.5'-3.0' SILTY CLAY, ~15% silt, low to med plasticity, with roots and other organics, some FeOx, dark grayish brown (10YR4/2), moist, soft, (pp=.5) CL	
	CME-2	57/60"		ML	3.0'-4.7' CLAYEY SILT, non plastic, ~25% clay, ~10% very fine sand, brown (10YR4/3), mottled with FeOx, dry to damp, hard (pp=2.75) CL	
5				CL	4.7'-9.3' CLAY, med. plasticity, some silt interbeds, abundant FeOx blebs, some MnOx, dark grayish brown (10YR4/2), damp, soft (pp=1.0) CL Silty fine sand lense from 7.8'-8.0'	
	CME-3	37/60"			9.3'-10.4' CL as above, with layers of lignite that cleave like pieces of wood, very dark gray (5Y3/1), damp to moist, soft to firm (pp=.75-1.25) CL	
10				SC	10.4'-11.1' SANDY CLAY, ~30% fine sand, some black coalified organics, very dark gray, moist, soft (pp=.25) CL	
					11.1'-13.0' No recovery	
	CME-4	56/60"			13.0'-15.0' SANDY CLAY as above, ~35% fine sand lenses up to 1", some lignite zones. CL	
15				CH	15.0'-15.3' CLAY, very high plasticity, dark gray (5Y4/1), some darker streaks, moist, very soft (pp=<.25) CH	
				CL	15.3'-15.4' SAND, fine-grained, dark gray. SP	
				CH / CL	15.4'-18.0' SILTY CLAY, low plasticity with crumbly zones to med. plasticity, with sandy silt interbeds to 2-1/2", very dark gray (5y3/1), moist to very moist, soft to hard (pp=.5-3.5) CL. CH at 17.0'-17.5', hard	
					Total depth 18.0'. Installed a temporary 2" diameter PVC monitoring well (QRSB-68D)	
20					Oxidizing/reducing contact at approximately 9.3 ft.	
25						

TEMPORARY WELL DIAGRAM

- Locking Cap
- Shale Trap
- 8" Open Hole
- Riser Casing: 2" ID Sch 40 PVC
- ---Static water level @ 13.1 ft 11/5/01
- Screen: 2" ID Sch 40 PVC, 10 Slot
- Bottom Cap And Total Well Depth 18.0-ft

ELEVATION feet: 455, 450, 445, 440, 435

Sample Interval | No Sample Taken | minimum | maximum | average

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BOREHOLE AND WELL COMPLETION LOG

TEMPWLOG

HOLE NUMBER	QRSB-69
SHEET 1 OF 1	
NORTH (Y):	1028159
EAST (X):	748161
TOC ELEVATION	457.1
GROUND ELEVATION	455.1
STICKUP	2.0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

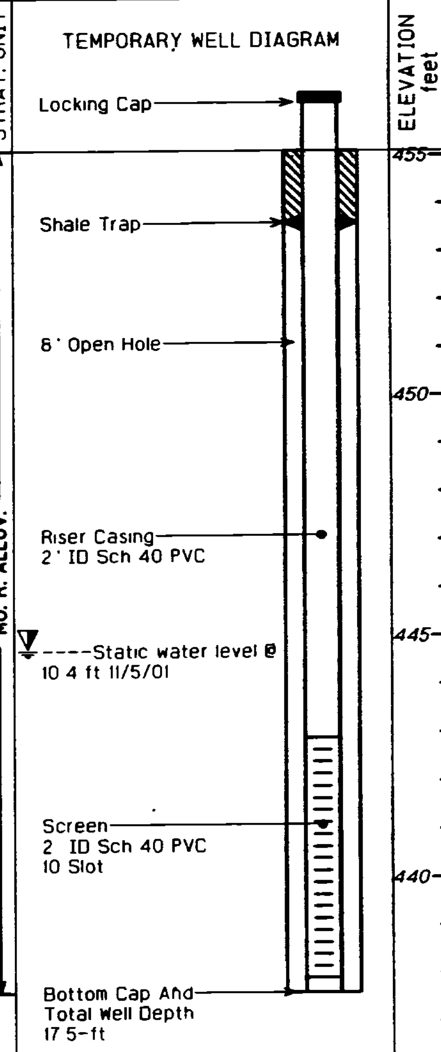
WELL STATUS/COMMENTS	TEMPORARY MONITORING WELL
LOCATION	QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-550
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
DEPTH (FT) FROM GROUND ELEV. TO: BOTTOM OF HOLE (TD)	17.5
BEDROCK	NOT ENCOUNTERED
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
WATER LEVELS & DATES	
DATE START	11/1/01
DATE FINISH	11/2/01

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
0	CME-1	23/29"	TOP SOIL	TOPSOIL	MO. R. ALLUV.
			CL	0 5'-2 5' SILTY CLAY, ~25% silt, ~15% fine sand, low plasticity, abundant roots, MnOx staining, brown (10YR4/3) CL	
	CME-2	55/60"	ML	2 5 -4 7' SANDY SILT, some clay interbeds, non to low plasticity, abundant FeOx, mottled brown (10YR5/3) and yellow brown (10YR5/6), damp to dry, soft (pp=1.0) ML	
5			CH	4.7'-5 0' CLAY, med to high plasticity, FeOx streaks, very dark gray (10YR3/1), damp, hard. CH	
			CL	5 0'-7 1' SILTY CLAY, low plasticity, ~25% silt, ~10% fine sand, MnOx streaks, damp, firm CL	
	CME-3	53/60"	ML	7 1'-8 8' CLAYEY SILT, some fine sand zones, with organics, FeOx to 7 5', varies from olive brown (2 5Y4/3) to dark gray (2 5Y4/1), dry to damp ML Black organics at 7.1'-7 5' and 8 1'-8 8'	
			CL	8 8'-10 6' SANDY SILTY CLAY, ~33% each, maybe more clay, sand in matrix and as a lense from ~9 5'-9 7', abundant black organics throughout, olive brown to dark gray as above, damp to moist, firm (pp=1 0) CL	
10			ML/CL	10 6'-14 5' CLAYEY SILT TO SILTY CLAY, low plasticity, minor organics, dark gray (5Y4/1), moist, soft (pp=<.25) ML/CL	
	CME-4	58/60"			
15			CH	14 5'-15 7' CLAY, high plasticity, no organics, dark gray, some mottling, moist, soft (pp=.75) CH	
				15 7'-16 3' CLAY, high plasticity, slightly silty, 1-1/2 partially coalified tree twig, moist, soft (pp= 5) CH	
			SP	16 3'-16 8' SILTY SAND, fine-grained, poorly graded, ~20% clay and silt, moist to wet SP	
			CH	16 8'-17 1' CLAY, very high plasticity as at 14 5' CH	
			ML	17 1'-17.3'. SANDY SILT, ~30% fine sand, some clay stringers, dark gray (5Y4/1), moist ML.	
			LIG	17 3'-17 5' LIGNITE, preserved thin wood shavings/bark remnants, black (5Y2.5/1), moist	
20				Total depth 17 5' Installed a temporary 2" diameter PVC monitoring well (QRSB-69D).	
				Oxidizing/reducing contact at approximately 7 5 ft	
25					

Column headings also printed: SAMPLE, N# or RQD, GRAPHIC LOG; PERCENT Recovery scale 0 100.

TEMPORARY WELL DIAGRAM



Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-70
SHEET 1 OF 1	
NORTH (Y):	1028460
EAST (X):	748313
TOC ELEVATION	
GROUND ELEVATION	462 9
STICKUP	
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS: ABANDONED BORING	LOCATION: QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-550

HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	BOTTOM OF HOLE (TD): 11 2
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: ~11.2
DATE START: 11/7/01	DATE FINISH: 11/7/01	WATER LEVELS & DATES

DEPTH (FT.) FROM GROUND ELEV TO:

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT	LABORATORY SAMPLES	ELEVATION feet
0–2.0	CME-1	29/29"		TOP SOIL	0 0-2 0' SILTY CLAY, low plasticity, minor sand, with tree roots, very dark gray (10YR3/1), CL Topsoil	MO. R. ALLUV.		
2.0–4.5	CME-2	60/60"		ML	2 0'-4 5' CLAYEY SILT, non plastic, ~20% clay and ~15% very fine sand, abundant roots, minor MnOx/FeOx, dry, soft (pp= 75) ML			460
4.5–7.5 (5)				CL	4 5'-7 5' SILTY CLAY, low plasticity, ~15% silt, minor MnOx/FeOx, very dark grayish brown (10YR3/2), dry to damp, very hard (pp=4 5) ML			
7.5–10.0	CME-3	43/44"		CH	7 5'-10 0' CLAY, med to high plasticity, some roots, increasing FeOx with depth, very dark gray (2 5Y3/1), damp, hard (pp=4 5) CH			455
10.0–11.2 (10)				CL	10 0'-11 2' SILTY CLAY, low plasticity, ~25-30% silt, increasing with depth, abundant roots and FeOx, damp, hard (pp=3 75) CL Limestone in end of sampler shoe The entire sequence is oxidized		Soil sample SO-100008S No well installed because of unsaturated conditions	
					Total depth 11 2' at auger refusal Boring backfilled with bentonite chips			450
15								

Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

TEMPHLOG

HOLE NUMBER	QRSB-71
SHEET 1 OF 1	
NORTH (Y):	1028159
EAST (X):	748161
TOC ELEVATION	457.2
GROUND ELEVATION	455.2
STICKUP	2.0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS: TEMPORARY MONITORING WELL	LOCATION: QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-550
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A
DATE START: 11/2/01	DATE FINISH: 11/2/01

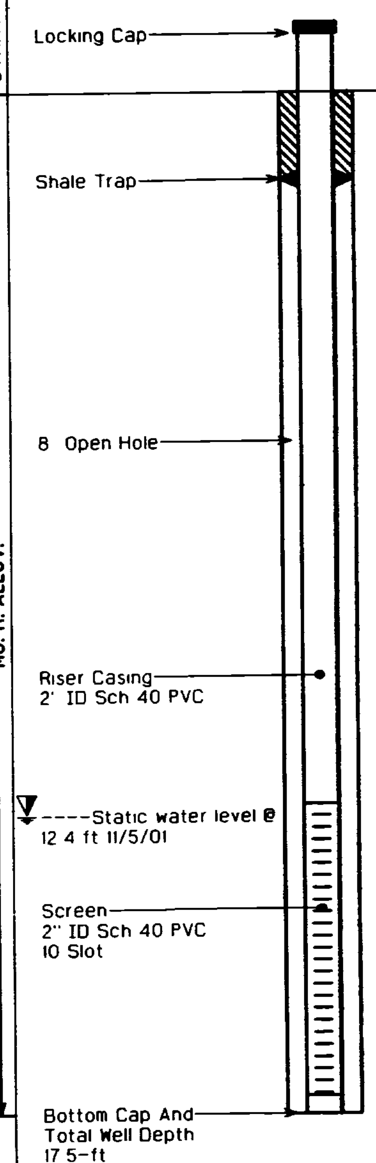
DEPTH (FT.) FROM GROUND ELEV. TO:

- BOTTOM OF HOLE (TD): 17.5
- BEDROCK: 17.5+
- WATER LEVELS & DATES

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT	ELEVATION feet
0	CME-1	29/29"	FILL	0 0'-3 1' SILTY CLAY, with roots and limestone gravel up to 2' Fill	MO. R. ALLUV.	455
	CME-2	50/60"	CL	3 1'-10 4'. SILTY CLAY, low plasticity, ~25-30% silt, ~10% fine sand as interbeds, abundant organics as roots, twigs and grass with FeOx replacement, some MnOx, mottled brown (10YR4/3) and dark yellowish brown (10YR4/6), moist, firm (pp= 5-1 5) CL		
5						450
	CME-3	35/60"	CL	Fine-grained sand lenses at 8 0'-8 2', 9 7'-9 9' and 10 0'-10 4'		
10			?	10 4'-13.0' No recovery. Oxidized/reduced contact likely within this zone near 10 4'.		445
	CME-4	56/60"	SP	13 0'-14 2' SAND, quartz, fine-grained, subrounded, poorly graded, contains black carbonaceous specks, abundant coalified wood, ~15% clay as lenses, very dark gray (5Y3/1) SP		
15			CH	14 2'-17.3' CLAY, very high plasticity, 1' pockets of fine-grained sand from 15 6'-16.1', very dark gray (5Y3/1), very moist, very soft (pp=<.25) CH		440
			SP	17 3'-17 5' SAND, as at 13 0', fine-grained, ~10% silt SP ~3 5" piece of limestone wedged in the sampler shoe; possibly near top of rock at ~17 5'		
				Total depth 17 5' Installed a temporary 2" diameter PVC monitoring well (QRSB-71D) Oxidizing/reducing contact estimated near 10 4 ft.		
20						435

TEMPORARY WELL DIAGRAM



Sample Interval ☐ No Sample Taken ∇minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

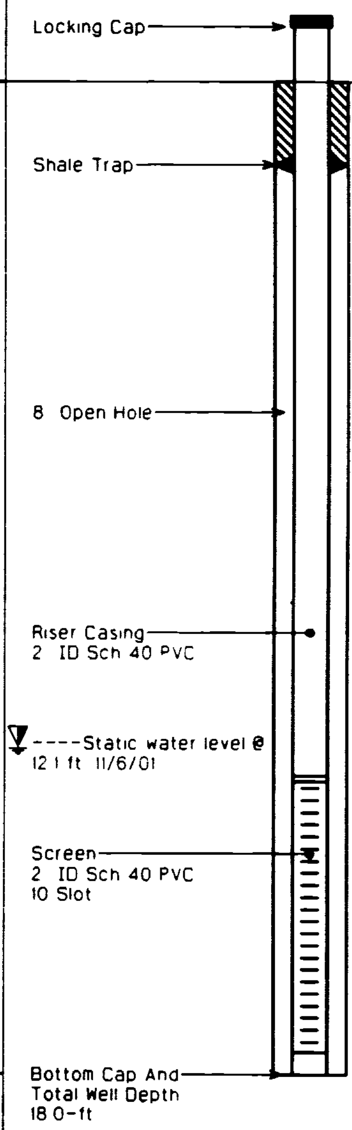
TEMPHLOG

HOLE NUMBER QRSB-72	**SHEET** 1 OF 1	**NORTH (Y):** 1028356	**EAST (X):** 748371
WELL STATUS/COMMENTS TEMPORARY MONITORING WELL	**LOCATION** QUARRY INTERCEPTOR TRENCH AREA	**TOC ELEVATION** 457	
DRILLING CONTRACTOR GEOTECHNOLOGY INC.	**DRILL RIG MAKE & MODEL** CME-550	**GROUND ELEVATION** 455	
HOLE SIZE & METHOD 7-1/4" HSA, 4" CME Sampler	**ANGLE FROM HORIZONTAL & BEARING** 90	**BOTTOM OF HOLE (TD)** 18 0	**STICKUP** 2 0
DRILL FLUIDS & ADDITIVES None	**CASING TYPE, DEPTH, SIZE** N/A	**BEDROCK** NOT ENCOUNTERED	**HYDR CONDUCTIVITY (cm/sec)** K= NOT DETERMINED
DATE START 11/5/01	**DATE FINISH** 11/5/01	**WATER LEVELS & DATES**	DEPTH (FT) FROM GROUND ELEV TO

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT	ELEVATION feet
	CME-1	25/35"		TOP SOIL	TOPSOIL with organics	NO. R. ALLUV.	
				CL	0 5'-2 8' SILTY CLAY, ~35% silt, low, plasticity, some MnOx and roots, brown (10YR5/3), moist, soft (pp=1 0) CL		
	CME-2	52/60"		ML	2 8'-3 7' CLAYEY SILT, non plastic, ~10% very fine sand, abundant FeOx/MnOx replacing organics, brown (10YR5/3), damp, very soft (pp=< 25) ML		
5				CL	3 7'-8 0' SILTY CLAY, as at 0 5', with silt interbeds, damp to moist CL		450
	CME-3	36/60"			8 0'-9 2' SILTY CLAY, very silty and some fine sand, both increase with depth to ~40% silt, very abundant FeOx organic replacement, dark grayish brown (2 5Y4/2), moist, soft (pp=1 0) CL		
				SP	9 2'-9 5' SAND, poorly graded, fine-grained, clean, dark yellowish brown (10YR4/4), damp, dense SP		
10				CL	9 5'-9 7' SANDY CLAY, ~30% very fine to fine sand, with MnOx blebs, dark gray (5Y4/1), very moist CL		445
				SP	9 7'-9 9' SAND, fine-grained, minor clay, olive brown (2 5Y4/3) with some FeOx, moist SP		
				CL	9 9'-11 2' SANDY CLAY, ~30% fine to medium sand, with black coalified wood and leaves, very dark gray (5Y3/1), moist to very moist, very soft CL		
	CME-4	60/60"		SP	11 2'-11 5' SAND, fine to medium-grained SP		
				?	11 5'-13 0' No recovery		
15				CL	13 0'-15 6' SILTY CLAY, med plasticity to 13 7', then low plasticity with some sand, partially coalified wood up to 1" in diameter, very dark gray (5Y3/1), moist, soft (pp= 75) CL		440
				CL	15 6'-17 0' SANDY CLAY, low plasticity, ~35% very fine sand, some coarser sand in interbeds up to ~1-1/4" thick, some silt, little to no organics, very dark gray (5Y3/1), moist, very soft (pp=< 25) CL		
				CH	17 0'-17 6' CLAY, very high plasticity, no organics, color as above, moist CH		
				SP	17 6'-18 0' SAND, fine with minor very fine-grained, subangular, minor clay and silt, some black organic specks, very dark gray (5Y3/1), moist to wet, med dense SP		
20					Total depth 18 0' Installed a temporary 2 diameter PVC monitoring well (QRSB-72D) Oxidizing/reducing contact at 10 0 ft		435

TEMPORARY WELL DIAGRAM



Sample Interval ☐ No Sample Taken ∇minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

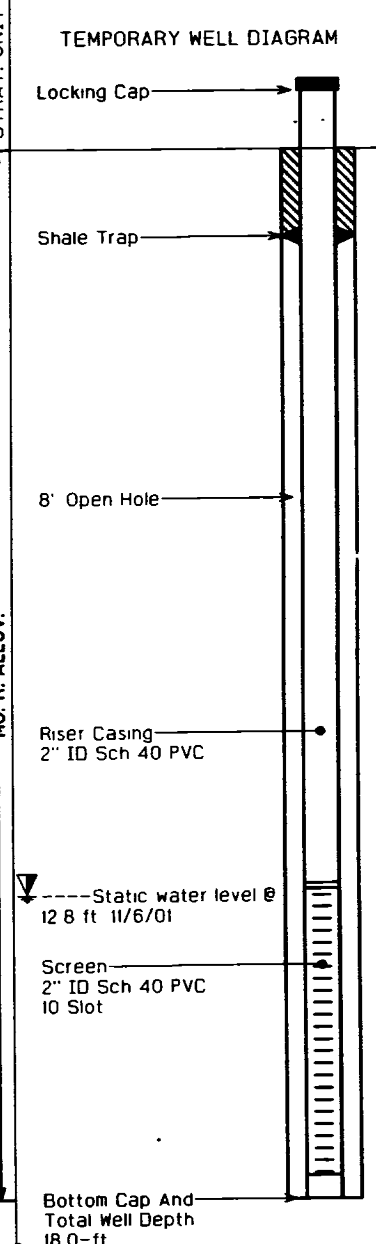
HOLE NUMBER	QRSB-73
SHEET 1 OF 1	
NORTH (Y):	1028302
EAST (X):	748401
TOC ELEVATION	457
GROUND ELEVATION	455
STICKUP	2.0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

TEMPMLOG

WELL STATUS/COMMENTS	TEMPORARY MONITORING WELL
LOCATION	QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-550
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
DEPTH (FT.) FROM GROUND ELEV TO: BOTTOM OF HOLE (TD)	18.0
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
BEDROCK	NOT ENCOUNTERED
DATE START	11/5/01
DATE FINISH	11/5/01
WATER LEVELS & DATES	

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	ELEVATION feet
	CME-1	23/35"	TOP SOIL	TOPSOIL with organics	MO. R. ALLUV.	
			CL	0 5'-3.0' SILTY CLAY, ~25% silt, low, plasticity, minor fine sand, FeOx blebs, abundant roots, some silt interbeds, brown (10YR4/3), at 3.0'-3 2' are wood chips in a plastic clay matrix, no silt, very dark gray, moist, very dense CL		
	CME-2	37/60"	ML	3 4'-4 3' SANDY SILT, ~20% sand as thin interbeds, abundant MnOx streaks, brown (10YR5/3), dry to damp, soft (pp= 75) ML		
5			SP	4 3'-5 4' SAND, very fine to fine-grained, poorly graded, subrounded quartz, some clayey zones, a clay interbed at 4 9'-5 1', FeOx stain, damp, med dense SP		450
			CL	5 4'-8 0' SILTY CLAY, low plasticity, ~25% silt, abundant MnOx, brown (10YR4/3), moist, firm (pp=1.5) CL		
	CME-3	38/60"	SP	8 0'-8 2' SAND, fine-grained, minor clay, heavy FeOx SP		
10			CL	8 2'-10 0' SILTY SANDY CLAY, low to med plasticity, FeOx streaks, brown (10YR4/3), grading down to very dark grayish brown (10YR3/2), moist to very moist, soft (pp= 5), silt increasing with depth and FeOx decreasing to absent at 10', black organics at 10' CL Gradational oxidized/reduced contact at 10'		445
			CL/ML	10 0'-11 2'. CLAYEY SILT, clay and silt, approx equal with 1 sand interbeds, black organics and clay zones, very dark grayish brown (2 5Y3/2), very moist to wet CL/ML		
			?	11 2'-13 0' No recovery.		
	CME-4	44/60"	SW	13 0'-13 9' SAND, fine to coarse-grained with a fine gravel lense at 13 8', rounded quartz, some clay-rich zones, very dark grayish brown (2 5Y3/2), moist to wet SW		
15			CL	13 9'-15.0' SILTY CLAY, med to high plasticity, minor interbedded sand, some black organics, very moist, very soft (pp= 25). CL		440
			SP	15 0'-15 8' SAND, fine-grained, grading to very fine, very dark gray (5Y3/1), wet, med dense SP		
			CH	15.8'-16 0' CLAY, very high plasticity, moist, very soft CH		
			ML	16 0'-16 2'. CLAYEY SILT, very dark gray (5Y3/1), wet ML		
			SM	16 2'-16 6' SILTY SAND, very fine-grained, ~25% silt, wet SM.		
			?	16 2'-18.0' No recovery		
20				Total depth 18 0' Installed a temporary 2' diameter PVC monitoring well (QRSB-73D) Oxidizing/reducing contact at 10 0' (gradational contact)		435



Sample Interval · No Sample Taken · ∇ minimum · ▼ maximum · ▼ average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

TEMPWLOG

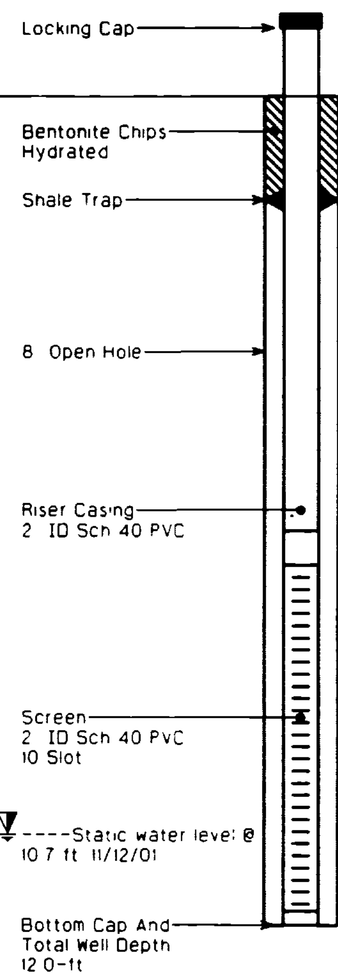
HOLE NUMBER QRSB-74	**SHEET** 1 **OF** 1	**NORTH (Y):** 1028552	**EAST (X):** 748516
WELL STATUS/COMMENTS TEMPORARY WELL	**LOCATION** QUARRY INTERCEPTOR TRENCH AREA	**TOC ELEVATION** 459.7	
DRILLING CONTRACTOR GEOTECHNOLOGY INC.	**DRILL RIG MAKE & MODEL** CME-550	**GROUND ELEVATION** 457.7	
HOLE SIZE & METHOD 7-1/4" HSA, 4" CME Sampler	**ANGLE FROM HORIZONTAL & BEARING** 90	**BOTTOM OF HOLE (TD)** 12 0	**STICKUP** 2.0
DRILL FLUIDS & ADDITIVES None	**CASING TYPE, DEPTH, SIZE** N/A	**BEDROCK** ~12 0	**HYDR CONDUCTIVITY (cm/sec)** K= NOT DETERMINED
DATE START 11/8/01	**DATE FINISH** 11/8/01	**WATER LEVELS & DATES**	DEPTH (FT.) FROM GROUND ELEV TO

LITHOLOGY BY Alan Benfer

DEPTH feet	SAMPLE/RUN Number	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT
0	CME-1	FILL / CL	0 0'-0 9' CLAY, very silty, with roots, trace limestone gravel, brown (10YR5/3), moist, firm CL Fill	NO. R. ALLUV.
		CL	0 9'-6 0' SILTY CLAY, med plasticity, some roots, minor MnOx, moist, firm (pp=1 5), hard (pp=2 5) at 3 5'-7 0' CL Native Soil	
	CME-2		@ 4 0' ~1/2 lense of silt, light gray, dry	
5		GP	6 0'-6 2' Lense of oxidized limestone gravel up to 2 ' in diameter, subangular GP	
	CME-3	CL CH	6 2'-11 0' CLAY, med to high plasticity, mottled dark grayish brown (10YR4/2) and reddish brown (FeOx), moist, hard (pp=2 5) CL/CH	
10		CL CH	10 0'-11 0' CLAY as above, trace of white, medium-grained limestone sand CL/CH	
		SM/ML	11 0'-12 0' SAND AND SILT, ~ equal amounts, sand is fine to very fine-grained, oxidized, brown (10YR4/3), wet, very soft SM/ML	
			Auger refusal at 12 0', probable top of rock	
			Total depth 12 0' Installed a temporary 2 diameter PVC monitoring well (QRSB-74S) Entire interval is oxidizing	
15				

SAMPLE | PERCENT Recovery 0 100 | N# or RQD | GRAPHIC LOG

TEMPORARY WELL DIAGRAM



ELEVATION feet: 455, 450, 445, 440

Sample Interval No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT
BORHOLE AND WELL COMPLETION LOG

HOLE NUMBER	QRSB-75
SHEET 1 OF 1	
NORTH (Y):	1028530
EAST (X):	748529
TOC ELEVATION	458.7
GROUND ELEVATION	456.7
STICKUP	2.0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

TEMPWLOG

WELL STATUS/COMMENTS	TEMPORARY WELL
LOCATION	QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR	GEOTECHNOLOGY INC.
DRILL RIG MAKE & MODEL	CME-550
HOLE SIZE & METHOD	7-1/4" HSA, 4" CME Sampler
ANGLE FROM HORIZONTAL & BEARING	90
DRILL FLUIDS & ADDITIVES	None
CASING TYPE, DEPTH, SIZE	N/A
DATE START	11/8/01
DATE FINISH	11/8/01
DEPTH (FT.) FROM GROUND ELEV. TO: BOTTOM OF HOLE (TD)	12.0
BEDROCK	12.5
WATER LEVELS & DATES	

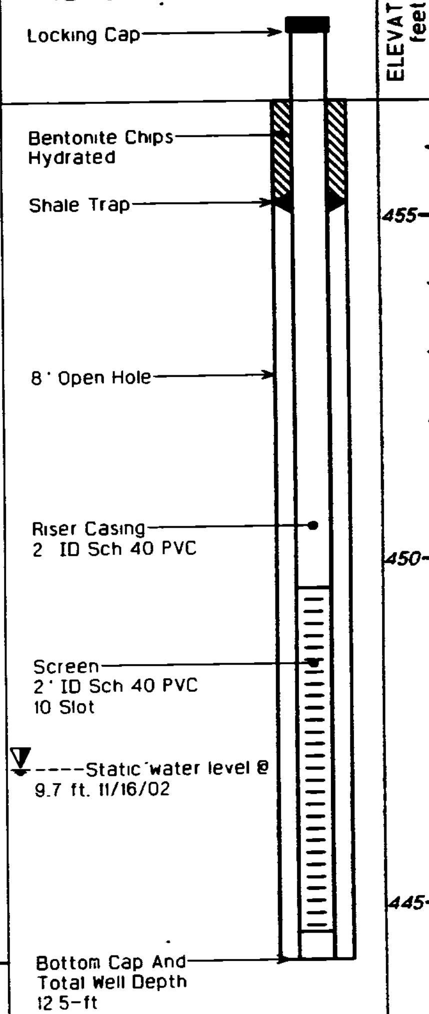
LITHOLOGY BY Alan Benfer

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT
0.0–3.0	CME-1	35/35"	FILL	0 0'-3 0'. CLAY, very silty, low plasticity, ~10% limestone gravel up to 1', abundant organics, mostly fresh, some oxidized, pale brown (10YR6/3), moist CL Fill	MO. R. ALLUV.
3.0–6.2	CME-2	54/60"	FILL	3 0'-6 2' SILT/CLAY, varies from clayey silt to very silty clay, low plasticity, ~10% limestone gravel, abundant organics, fresh, oxidized and carbonized, olive gray (5Y4/2), moist ML/CL Prabable Fill	MO. R. ALLUV.
6.2–8.9	CME-3	54/54"	CL	6 2'-8 9' SILTY CLAY, low plasticity, with carbonized organics, a few very thin lenses of fine to very fine silty sand, abundant streaks of FeOx, organics, so .e are brown (10YR5/3) and some olive gray, very moist, very soft CL	MO. R. ALLUV.
8.9–9.5			SM	8 9'-9 5' SILTY SAND, fine to very fine-grained, ~15% silt, some oxidation, brown, WET SM	MO. R. ALLUV.
9.5–10.8			ML	9 5'-10 8' SILT, clayey ML	MO. R. ALLUV.
10.8–11.0				10 8'-11 0' 2 thick wet sand lense	MO. R. ALLUV.
11.0–12.5			CL	11 0'-12.5' SILTY CLAY, med plasticity, with oxidized organics, olive gray and brown, moist, firm to hard (pp=2 0) CL Weathered limestone in tip of shoe	MO. R. ALLUV.

Entire sequence appears to be oxidized

Total depth 12 5' Installed a temporary 2' diameter PVC monitoring well (QRSB-75S) Entire drilled interval is oxidizing

TEMPORARY WELL DIAGRAM



Sample Interval ☐ No Sample Taken ▽ minimum ▼ maximum ▼ average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE AND WELL COMPLETION LOG

TEMPWLOG

HOLE NUMBER	QRSB-76
SHEET 1 OF 1	
NORTH (Y):	1028507
EAST (X):	748541
TOC ELEVATION	456.8
GROUND ELEVATION	454.8
STICKUP	2 0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS: TEMPORARY WELL	LOCATION: QUARRY INTERCEPTOR TRENCH AREA	
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-550	
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	BOTTOM OF HOLE (TD): 13 8
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: 13 8
DATE START: 11/8/01	DATE FINISH: 11/8/01	WATER LEVELS & DATES

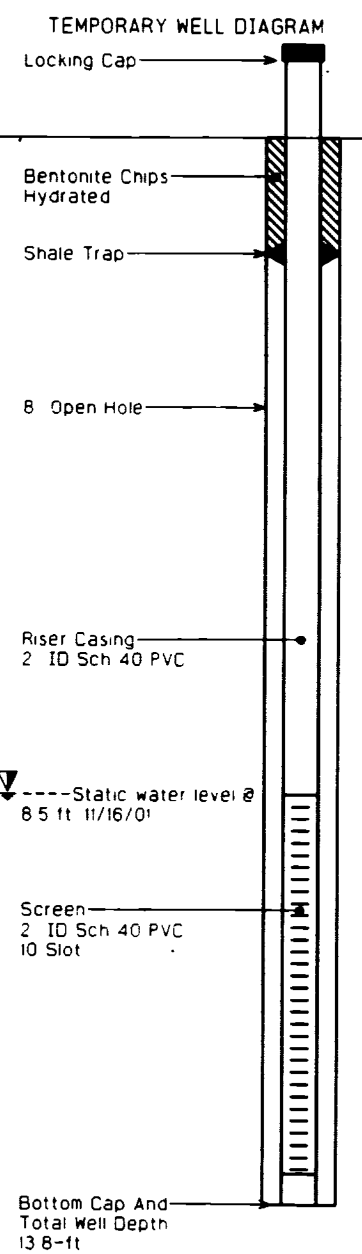
DEPTH (FT.) FROM / GROUND ELEV TO

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	SOIL/ROCK class	DESCRIPTION AND REMARKS
	CME-1	31/35"	FILL	0 0'-3 0' CLAY, low plasticity, ~15% angular limestone gravel up to 3", some sand, FeOx throughout, slightly moist, hard (pp=2 5) CL Fill
	CME-2	40/60"		3 0'-4 6' CLAY as above, abundant roots, very dark gray (5Y3/1), CL Fill
5			CH	4 6'-5 4' CLAY, slightly silty, med to high plasticity, with black coalified wood, dark olive gray (5Y3/2), moist to very moist, very soft (pp=< 25) CH
			CL	5 4'-6 0' CLAY, very silty, low plasticity, ~20% FeOx streaks, oxidized and carbonized organics, grayish brown (2 5Y5/2), moist, soft to firm (pp=1 0) CL
			?	6 0'-6 6' CLAY as above, with a few thin (~ 2mm) stringers of fine to very fine sand CL
				6 6'-8 0' No sample recovery Oxidation/reduction contact is within this interval
	CME-3	48/60"	ML	8 0'-8 6' CLAYEY SILT, ~30% clay, ~10% very fine sand, reduced, dark gray (2 5Y4/1), very moist ML
			CL	8 6'-9 2' SILTY CLAY, low plasticity, some very fine sand, black organic streaks, dark gray (2 5Y4/1), moist CL
10			SC	9 2'-10 2' CLAYEY SAND, very fine-grained, ~30% clay and silt, black organics, dark gray (2 5Y4/1), moist SC
			CL	10 2'-11 1' SILTY SANDY CLAY, low plasticity, textures laminated, some black organics, dark gray, very moist CL
			SC	11 1'-11 3' CLAYEY SAND, as at 9 2', fine-grained, ~10% silt SC
			CL	11 3'-12 0' SILTY CLAY, low plasticity, ~25% silt, ~10% very fine sand, abundant carbonized organics, black pieces of wood at 11 7'- 12 0', very moist CL
	CME-4	6/10"	?	12 0'-13 0' No sample recovery
			LIG	13 0'-13 3' Carbonized organics
			?	13 3'-13 8' No recovery
15				Total depth 13 8' Installed a temporary 2 diameter PVC monitoring well (QRSB-76D) Oxidizing/reducing zone contact at approximately 7 5 ft (within loss zone)

STRAT UNIT: MO. R. ALLUV.

ELEVATION feet: 450, 445, 440



Sample Interval · No Sample Taken · minimum · maximum · average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER		QRSB-77
SHEET 1 OF 1		
NORTH (Y):		1028488
EAST (X):		748554
TOC ELEVATION		
GROUND ELEVATION		453.5
STICKUP		
HYDR CONDUCTIVITY (cm/sec)		K= Not Determined

WELL STATUS/COMMENTS: TEMPORARY WELL	LOCATION: QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-550
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A
DATE START: 11/7/01	DATE FINISH: 11/7/01

DEPTH (FT.) FROM GROUND ELEV. TO:
- BOTTOM OF HOLE (TD): 13.0
- BEDROCK: Not Encountered
- WATER LEVELS & DATES: ∇ ▼

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
0	CME-1	25/35"		TOP SOIL	0 0'-0.5' TOPSOIL	NO. R. ALLUV.		
				CI	0 5'-2.0' SILTY CLAY, low plasticity, ~25-30% silt, with roots and organics, brown (10YR4/3) with FeOx mottling and some MnOx, damp to moist, firm CL			
	CME-2	48/60"		CL CH	2 0'-7 0'. SILTY CLAY, ~15% silt, med plasticity, some silty sand lenses, abundant organics replaced with FeOx, brown (10YR4/3), moist to very moist, very soft (pp=.25). CL-CH			450
5							----Water level in QRSB-64S @ 5 5' Sample SO-100015S	
				?	7 0'-8 0' No sample recovery Oxidized/reduced contact possibly within this zone, maybe at ~7 5'		----Water level in QRSB-64D @ 7 6'	
	CME-3	60/60"		CL	8 0'-10 4' SILTY CLAY, low to med plasticity, ~20% silt, decreasing to ~5% with depth, with ~10% sand at 8 5'-9 0', abundant black organics throughout, very dark gray (5Y3/1), moist to very moist, soft (pp=5) CL			445
10				CH	10 4'-13 0' CLAY, med. to high plasticity, sandy at 12 2'-12 4' with a sand lense at 12.4'-12 5', black organics throughout, very dark gray (5Y3/1), very moist CH		Sample SO-100015D*	
				CH				
					Total depth 13 0'. Installed 2 temporary 2 diameter PVC monitoring wells for oxidizing and reducing water conditions Oxidizing/reducing contact at approximately 7.5 ft (within loss zone)		*Collected biased samples for uranium analysis in addition to the composite sample Biased sampled intervals were from 8.2-9', 9-10', 10-11', and 11-12'	440
15					NOTE 8.0'-8 2' interval recorded 356cpm for 1 min. Analysis indicated 148 pCI/g, U238		Installed paired temporary wells screened as follows: QRSB-77S: 1 6-6 6 ft; QRSB-77D 7 6-12 6 ft.	
								435
20								

▮ Sample Interval ☐ No Sample Taken ∇minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BORNEHOLE AND WELL COMPLETION LOG

HOLE NUMBER	QRSB-79
SHEET 1 OF 1	
NORTH (Y):	1028670
EAST (X):	748854
TOC ELEVATION	148.6
GROUND ELEVATION	456.6
STICKUP	2.0
HYDR CONDUCTIVITY (cm/sec)	K= Not Determined

TEMPWLOG

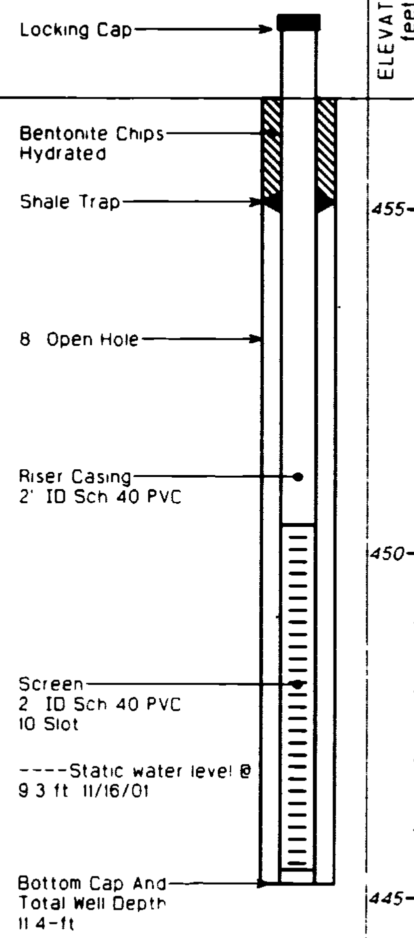
WELL STATUS/COMMENTS: TEMPORARY WELL	LOCATION: QUARRY INTERCEPTOR TRENCH AREA	
DRILLING CONTRACTOR: GEOTECHNOLOGY INC.	DRILL RIG MAKE & MODEL: CME-550	
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	BOTTOM OF HOLE (TD): 11 4
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: 11 4
DATE START: 11/14/01	DATE FINISH: 11/14/01	WATER LEVELS & DATES

DEPTH (FT) FROM GROUND ELEV TO

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT
	CME-1	27/35"		CH	0 0'-1 0' CLAY, med to high plasticity, abundant roots, very dark grayish brown (10YR3/2), moist, firm CH	NO. R. ALLUV.
				CL	1 0'-2 5' SILTY CLAY, low to med plasticity, ~25% silt, with roots, some silty pockets, minor MnOx, mottled dark grayish brown (10YR4/2) and minor brown (10YR4/3), damp CL	
	CME-2	60/60"		CL CH	2 5'-5 5' CLAY, med to high plasticity, very blocky texture, very dark grayish brown (10YR3/2) with abundant yellowish red (5YR4/6) hematite in matrix and replacing organics, damp, hard (pp=3 5) Very plastic from 3 0' to 3 8', calcium carbonate concretions up to 1/2 from 4 6' CL/CH	
5					5 5'-7 3' CLAY, med plasticity, slightly silty, increases with depth, some silt lenses, blocky texture, some FeOx, mottled grayish brown (2 5Y5/2) and yellowish brown (10YR5/6), damp, hard (pp=2 25) CL-CH	
	CME-3	41/41"		SC SM	7 3'-8 9' SAND, very fine to fine-grained, poorly graded, ~20% silt and clay in matrix as well as laminated with the sand, dark grayish brown (2 5Y4/2) with orange FeOx blebs, moist SC-SM	
10				CL CH	8 9'-11 0' CLAY, med to high plasticity, with abundant FeOx as alteration and as streaks, sandy and silty from 9 6', dark grayish brown (2 5Y4/2) moist, hard (PP=3 5) CL-CH	
				SC SM	11 0'-11 4' SAND, clayey and silty as at 7 3', WET SC-SM Limestone in tip of sampler shoe, sampler refusal at 11 4', likely top of rock The entire sequence is oxidized	
15					Total depth 11 4' Installed a temporary 2' diameter PVC monitoring well (QRSB-79S)	

TEMPORARY WELL DIAGRAM



ELEVATION feet

Sample Interval No Sample Taken minimum maximum average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-80	SHEET 1 OF 1	
NORTH (Y): 1028628	EAST (X): 748866	TOC ELEVATION	GROUND ELEVATION 457.5
STICKUP	HYDR CONDUCTIVITY (cm/sec) K= NOT DETERMINED		
WELL STATUS/COMMENTS: TEMPORARY MONITORING WELL	LOCATION: QUARRY INTERCEPTOR TRENCH AREA		
DRILLING CONTRACTOR: GEOTECHNOLOGY INC	DRILL RIG MAKE & MODEL: CME-550		
HOLE SIZE & METHOD: 7-1/4" HSA, 4" CME Sampler	ANGLE FROM HORIZONTAL & BEARING: 90	DEPTH (FT) FROM GROUND ELEV TO: BOTTOM OF HOLE (TD): 15.0	
DRILL FLUIDS & ADDITIVES: None	CASING TYPE, DEPTH, SIZE: N/A	BEDROCK: ~15.0	
DATE START: 11/13/01	DATE FINISH: 11/13/01	WATER LEVELS & DATES	

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES	ELEVATION feet
0	CME-1	23/29"	CL	0.0'-3.5' SILTY CLAY, ~15% silt, low to med plasticity, with roots and other organics, minor MnOx near the surface, very dark grayish brown (10YR3/2), damp CL	MO. R. ALLUV.		457.5
	CME-2	60/60"	CH	3.5'-8.6' CLAY, med to high plasticity, blocky texture, roots and black organics with abundant FeOx replacement and as fracture filling, possibly CaCO3 filling, mottled very dark grayish brown (10YR3/2) and yellowish red (5YR4/6), damp, very hard (pp=4.0) CH			455
5	CME-3	60/60"					450
			SC	8.6'-11.2'. CLAYEY SAND, fine-grained, poorly graded, laminated with clay and clay-rich in layers 1.0mm-10mm thick, dark grayish brown, very moist to wet SC		----Water level in QRSB-80D @9.6'	
10						----Water level in QRSB-80S @10.2'	
			CL	11.2'-11.7' SILTY CLAY, some very fine sand, with FeOx replacement of organics, minor CaCO3 concretions, dark grayish brown (2.5Y4/2), moist, soft (pp=.75) CL		Sample SO-100018S	
	CME-4	30/30"	SC	11.7'-12.1' CLAYEY SAND as at 8.6', dark gray (2.5Y4/1), with FeOx nodules at 12.0' SC.			445
			CH	12.1'-12.4' SANDY CLAY as above, but more clay than sand CL		Sample SO-100018D	
			SP	12.4'-12.8' CLAY, very high plasticity, tiny blebs of hematite, dark gray (5Y4/1) with strong brown (7.5YR4/6), very moist, very soft (pp=<.25) CH			
			CL CH	12.8'-13.0' SAND, very fine-grained, poorly graded, ~10% silt, some clay, no FeOx, WET. SP Transitional oxidation/reduction contact at ~12.8'			
				13.0'-13.6'. SANDY CLAY, high plasticity, ~15% very fine sand, displays slump bedding, dark gray and strong brown as above, moist. CH.			
				13.6'-14.8' SANDY CLAY, as above, med. plasticity, with sand lenses and increased stiffness CL-CH.			
15			ML	14.8'-15.0' SANDY SILT, non plastic, ~10% sand and clay, dark gray and strong brown, very moist to wet ML		Installed paired temporary wells screened as follows: QRSB-80S 6.3-11.3' and QRSB-80D 13-15'	440
				Sampler refusal at 15.0' Probable top of rock			
20				Total depth 15.0' Installed one 2 and one 3/4' temporary monitoring wells for oxidized and reduced water conditions. Oxidizing/reducing contact at 12.8 ft (gradational contact)..			

▮ Sample Interval ☐ No Sample Taken ▽minimum ▼maximum ▼average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-81
SHEET 1 OF 1	
NORTH (Y):	1028300
EAST (X):	748005
TOC ELEVATION	464.4
GROUND ELEVATION	464 4
STICKUP	0 0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS: QROU FIELD STUDIES, GEOCHEM CHARACTER	LOCATION: QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR: GEOTECHNOLOGY, INC	DRILL RIG MAKE & MODEL: CME-550 ALL TERRAIN
HOLE SIZE & METHOD: 7-1/4" HSA, NQWL CORE	ANGLE FROM HORIZONTAL & BEARING: 90
DRILL FLUIDS & ADDITIVES: WATER	CASING TYPE, DEPTH, SIZE: n/a
DATE START: 11-16-01	DATE FINISH: 11-16-01

DEPTH (FT) FROM GROUND ELEV TO:

- BOTTOM OF HOLE (TD): 26 0
- BEDROCK: 16 5
- WATER LEVELS & DATES: ▽ ▼

LITHOLOGY BY: Paul Patchin

DEPTH feet	SAMPLE	SAMPLE/RUN Number	PERCENT Recovery (0–100)	N# or RQD	GRAPHIC LOG	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT UNIT	LABORATORY SAMPLES	ELEVATION feet
0–16.5							The overburden soil was not sampled or logged from the surface to 16 5-ft	UNDIFF. MO. R. ALLUV.		
5										460
10										455
15							Auger refusal at 16 5-ft Continue with NQWL core			450
		RUN-1	26/36"	0		LMS SH	16 5'-23 2 LIMESTONE AND SHALE, ~80% limestone and ~20% shale Limestone is light olive gray (5Y6/1), finely crystalline, slightly weathered, very thinly bedded, closely fractured, fossiliferous, moderately hard, low porosity, with FeOx-rich clay on some fractures Shale is olive gray (5Y4/1), very thinly bedded, very fossiliferous, some wavy bedding Decorah Group	DECORAH GROUP	▽---Static water level in adjacent well OW-1 @17 15'	
20		RUN-2	11/12"	50			Loss zones unknown for Run-1			445
		RUN-3	8/12"	70			Lost circulation permanently at 17-ft		Sample SO-100019	
		RUN-4	54/54"	40			23 2'-24 7' LIMESTONE AND SHALE as above Limestone is coarser crystalline, med light gray (N6), increase in fossils Shale is dark greenish gray (5G4/1) and soft			
25							24 7'-26 0' SHALE, dark greenish gray, moderately weathered, soft, fissile, with FeOx-rich clay in partings, very thinly bedded, minor fossils Limestone bed at 25 7'-25 9', very fossiliferous (Decorah Group)			440
							Total depth 26 0' Boring backfilled with bentonite slurry from the bottom up using a tremie pipe			
30							NOTE Collected composite sample #SO-100019 which is the entire core fron 16 5'-25 4' This zone mirrors the monitored interval in well OW-1 located 8-ft to the northeast			435
35										430

■ Sample Interval □ No Sample Taken ▽minimum ▼maximum ▽average

WELDON SPRING SITE REMEDIAL ACTION PROJECT

BOREHOLE LOG

GEOLOG-C

HOLE NUMBER	QRSB-82
SHEET 1 OF 1	
NORTH (Y):	1028405
EAST (X):	748186
TOC ELEVATION	463.2
GROUND ELEVATION	463.2
STICKUP	0.0
HYDR CONDUCTIVITY (cm/sec)	K= NOT DETERMINED

WELL STATUS/COMMENTS	GROU FIELD STUDIES, GEOCHEM. CHARACTER
LOCATION	QUARRY INTERCEPTOR TRENCH AREA
DRILLING CONTRACTOR	GEOTECHNOLOGY, INC
DRILL RIG MAKE & MODEL	CME-550 ALL TERRAIN
HOLE SIZE & METHOD	7-1/4" HSA, NQWL CORE
ANGLE FROM HORIZONTAL & BEARING	90
DEPTH (FT.) FROM GROUND ELEV TO. BOTTOM OF HOLE (TD)	24 8
DRILL FLUIDS & ADDITIVES	WATER
CASING TYPE, DEPTH, SIZE	n/a
BEDROCK	14 6
DATE START	11-19-01
DATE FINISH	11-19-01
WATER LEVELS & DATES	

LITHOLOGY BY Paul Patchin

DEPTH feet	SAMPLE/RUN Number	PERCENT Recovery (0–100)	N# or RQD	SOIL/ROCK class	DESCRIPTION AND REMARKS	STRAT. UNIT	LABORATORY SAMPLES
0–14.6					The overburden soil was not sampled or logged from the surface to 14 6-ft	UNDIFF. MO. R. ALLUV.	
					Auger refusal at 14 6-ft Continue with NQWL core		
15	RUN-1	10/11"	0	LMS SH	14 6'-23 7 LIMESTONE AND SHALE, ~80% limestone and ~20% shale interbedded together Limestone is light olive gray (5Y6/1), finely crystalline, slightly weathered, thin to very thinly bedded, closely fractured, hard, low porosity, with FeOx staining from 14 6' to 16 6' Shale is olive gray (5Y4/1), very thinly bedded, very fossiliferous, some wavy bedding, moderately hard, slightly weathered Decorah Group.	DECORAH GROUP	---Static water level in adjacent well OW-4 @15 6'
	RUN-2	13/13"	27				
	RUN-3	24/24"	20				
	RUN-4	36/36"	67		~70-100% fluid return for Run-1 through Run-5		Sample SO-100020
	RUN-5	38/38"	47		23 7'-24 7' LIMESTONE AND SHALE as above, limestone is fine to medium-grained. Shale is more stringer-like, unit is less weathered		
					24 7'-24.8'. SHALE, dark greenish gray (5G4/1), interbedded with limestone, soft and fissle Decorah Group		
25					Total depth 24 8' Boring backfilled with bentonite grout from the bottom up using a tremie pipe		
					NOTE Collected composite sample SO-100020 which is the entire core interval from 14 6'-24 8' This zone mirrors the monitored interval in well OW-4 adjacent to this boring		

Depth scale (feet): 5, 10, 15, 20, 25, 30, 35

Elevation scale (feet): 460, 455, 450, 445, 440, 435, 430

Sample Interval ☐ No Sample Taken ∇minimum ▼maximum ▼average

Appendix B
Analytical Data/Geotechnical Testing Data/Test Methods

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
IS-OW01-111501	OW01	11/15/2001	URANIUM, TOTAL	268	9.48	0.0744	PCI/L		*
IS-OW04-111501	OW04	11/15/2001	URANIUM, TOTAL	2650	93.1	0.744	PCI/L		*
IS-QR63-S	QR63	10/31/2001	CHLORIDE	44.7		0.125	MG/L		*
IS-QR63-S	QR63	10/31/2001	NITRATE-N	0.15		0.0069	MG/L		*
IS-QR63-S	QR63	10/31/2001	SULFATE	191		0.31	MG/L		*
IS-QR63-S	QR63	10/31/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR63-S	QR63	10/31/2001	CALCIUM	259000		24.7	UG/L		*
IS-QR63-S	QR63	10/31/2001	IRON	1.12		2.24	UG/L		*
IS-QR63-S	QR63	10/31/2001	MAGNESIUM	52000		5.14	UG/L		*
IS-QR63-S	QR63	10/31/2001	MANGANESE	7.83		0.369	UG/L		*
IS-QR63-S	QR63	10/31/2001	POTASSIUM	2480		18.2	UG/L		*
IS-QR63-S	QR63	10/31/2001	SILICON	14100		9.9	UG/L		*
IS-QR63-S	QR63	10/31/2001	SODIUM	23100		15	UG/L		*
IS-QR63-S	QR63	10/31/2001	ALKALINITY	627		0.725	MG/L		*
IS-QR63-S	QR63	10/31/2001	URANIUM, TOTAL	399	13.5	0.149	PCI/L		*
IS-QR64-S	QR64	10/29/2001	CHLORIDE	32.4		0.125	MG/L		*
IS-QR64-D	QR64	10/29/2001	CHLORIDE	35		0.125	MG/L		*
IS-QR64-D	QR64	10/29/2001	NITRATE-N	0.05		0.0069	MG/L		*
IS-QR64-S	QR64	10/29/2001	NITRATE-N	0.08		0.0069	MG/L		*
IS-QR64-S	QR64	10/29/2001	SULFATE	140		0.31	MG/L		*
IS-QR64-D	QR64	10/29/2001	SULFATE	121		0.31	MG/L		*
IS-QR64-S	QR64	10/29/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR64-D	QR64	10/29/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR64-S	QR64	10/29/2001	CALCIUM	197000		24.7	UG/L		*
IS-QR64-D	QR64	10/29/2001	CALCIUM	186000		24.7	UG/L		*
IS-QR64-D	QR64	10/29/2001	IRON	4770		2.24	UG/L		*
IS-QR64-S	QR64	10/29/2001	IRON	19.2		2.24	UG/L		*
IS-QR64-S	QR64	10/29/2001	MAGNESIUM	45000		5.14	UG/L		*
IS-QR64-D	QR64	10/29/2001	MAGNESIUM	43200		5.14	UG/L		*
IS-QR64-S	QR64	10/29/2001	MANGANESE	28.7		0.369	UG/L		*
IS-QR64-D	QR64	10/29/2001	MANGANESE	1090		0.369	UG/L		*
IS-QR64-D	QR64	10/29/2001	POTASSIUM	4230		18.2	UG/L		*
IS-QR64-S	QR64	10/29/2001	POTASSIUM	1880		18.2	UG/L		*
IS-QR64-D	QR64	10/29/2001	SILICON	14700		9.9	UG/L		*
IS-QR64-S	QR64	10/29/2001	SILICON	12300		9.9	UG/L		*
IS-QR64-D	QR64	10/29/2001	SODIUM	18400		15	UG/L		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
IS-QR64-S	QR64	10/29/2001	SODIUM	20200		15	UG/L		*
IS-QR64-D	QR64	10/29/2001	ALKALINITY	599		0.725	MG/L		*
IS-QR64-S	QR64	10/29/2001	ALKALINITY	464		0.725	MG/L		*
IS-QR64-S	QR64	10/29/2001	URANIUM, TOTAL	902	30.5	0.744	PCI/L		*
IS-QR64-D	QR64	10/29/2001	URANIUM, TOTAL	294	10	0.0744	PCI/L		*
IS-QR65-D	QR65	10/25/2001	CHLORIDE	25.1		0.125	MG/L		*
IS-QR65-S	QR65	12/03/2001	CHLORIDE	17.1		0.05	MG/L		*
IS-QR65-D	QR65	10/25/2001	NITRATE-N	0.05		0.0069	MG/L		*
IS-QR65-S	QR65	12/03/2001	NITRATE-N	0.01		0.0069	MG/L		*
IS-QR65-D	QR65	10/25/2001	SULFATE	91.7		0.31	MG/L		*
IS-QR65-S	QR65	12/03/2001	SULFATE	83.4		0.124	MG/L		*
IS-QR65-D	QR65	10/25/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR65-S	QR65	12/03/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR65-D	QR65	10/25/2001	CALCIUM	176000		24.7	UG/L		*
IS-QR65-S	QR65	12/03/2001	CALCIUM	145000		24.7	UG/L		*
IS-QR65-D	QR65	10/25/2001	IRON	22200		2.24	UG/L		*
IS-QR65-S	QR65	12/03/2001	IRON	10.8		2.24	UG/L		*
IS-QR65-D	QR65	10/25/2001	MAGNESIUM	40700		5.14	UG/L		*
IS-QR65-S	QR65	12/03/2001	MAGNESIUM	30600		5.14	UG/L		*
IS-QR65-D	QR65	10/25/2001	MANGANESE	1480		0.369	UG/L		*
IS-QR65-S	QR65	12/03/2001	MANGANESE	281		0.369	UG/L		*
IS-QR65-D	QR65	10/25/2001	POTASSIUM	5220		18.2	UG/L		*
IS-QR65-S	QR65	12/03/2001	POTASSIUM	1670		18.2	UG/L		*
IS-QR65-D	QR65	10/25/2001	SILICON	22200		9.9	UG/L		*
IS-QR65-S	QR65	12/03/2001	SILICON	8170		9.9	UG/L		*
IS-QR65-D	QR65	10/25/2001	SODIUM	24800		15	UG/L		*
IS-QR65-S	QR65	12/03/2001	SODIUM	19300		15	UG/L		*
IS-QR65-D	QR65	10/25/2001	ALKALINITY	472		0.725	MG/L		*
IS-QR65-S	QR65	12/03/2001	ALKALINITY	423		1.45	MG/L		*
IS-QR65-D	QR65	10/25/2001	URANIUM, TOTAL	3.43	0.0496	0.0744	PCI/L		*
IS-QR65-S	QR65	12/03/2001	URANIUM, TOTAL	7.08	0.273	0.0744	PCI/L		*
IS-QR67-D	QR67	11/01/2001	CHLORIDE	17.7		0.025	MG/L		*
IS-QR67-D	QR67	11/01/2001	NITRATE-N	0.04		0.0069	MG/L		*
IS-QR67-D	QR67	11/01/2001	SULFATE	80		0.31	MG/L		*
IS-QR67-D	QR67	11/01/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR67-D	QR67	11/01/2001	CALCIUM	220000		24.7	UG/L		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
IS-QR67-D	QR67	11/01/2001	IRON	15600		2.24	UG/L		*
IS-QR67-D	QR67	11/01/2001	MAGNESIUM	60100		5.14	UG/L		*
IS-QR67-D	QR67	11/01/2001	MANGANESE	3300		0.369	UG/L		*
IS-QR67-D	QR67	11/01/2001	POTASSIUM	2840		18.2	UG/L		*
IS-QR67-D	QR67	11/01/2001	SILICON	22400		9.9	UG/L		*
IS-QR67-D	QR67	11/01/2001	SODIUM	26900		15	UG/L		*
IS-QR67-D	QR67	11/01/2001	ALKALINITY	691		0.725	MG/L		*
IS-QR67-D	QR67	11/01/2001	URANIUM, TOTAL	1.09	0.04	0.0744	PCI/L		*
IS-QR68-D	QR68	11/01/2001	URANIUM, TOTAL	1.12	0.031	0.0744	PCI/L		*
IS-QR69-D	QR69	11/05/2001	CHLORIDE	11.7		0.025	MG/L		*
IS-QR69-D	QR69	11/05/2001	NITRATE-N	0.03		0.0069	MG/L		*
IS-QR69-D	QR69	11/05/2001	SULFATE	0.031		0.062	MG/L		*
IS-QR69-D	QR69	11/05/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR69-D	QR69	11/05/2001	CALCIUM	147000		24.7	UG/L		*
IS-QR69-D	QR69	11/05/2001	IRON	41700		2.24	UG/L		*
IS-QR69-D	QR69	11/05/2001	MAGNESIUM	37800		5.14	UG/L		*
IS-QR69-D	QR69	11/05/2001	MANGANESE	2130		0.369	UG/L		*
IS-QR69-D	QR69	11/05/2001	POTASSIUM	7130		18.2	UG/L		*
IS-QR69-D	QR69	11/05/2001	SILICON	21300		9.9	UG/L		*
IS-QR69-D	QR69	11/05/2001	SODIUM	35300		15	UG/L		*
IS-QR69-D	QR69	11/05/2001	ALKALINITY	617		0.725	MG/L		*
IS-QR69-D	QR69	11/05/2001	URANIUM, TOTAL	0.044	0.002	0.0744	PCI/L		*
IS-QR71-D	QR71	11/05/2001	CHLORIDE	9.95		0.025	MG/L		*
IS-QR71-D	QR71	11/05/2001	NITRATE-N	0.03		0.0069	MG/L		*
IS-QR71-D	QR71	11/05/2001	SULFATE	1.9		0.062	MG/L		*
IS-QR71-D	QR71	11/05/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR71-D	QR71	11/05/2001	CALCIUM	167000		24.7	UG/L		*
IS-QR71-D	QR71	11/05/2001	IRON	8930		2.24	UG/L		*
IS-QR71-D	QR71	11/05/2001	MAGNESIUM	33600		5.14	UG/L		*
IS-QR71-D	QR71	11/05/2001	MANGANESE	3950		0.369	UG/L		*
IS-QR71-D	QR71	11/05/2001	POTASSIUM	4020		18.2	UG/L		*
IS-QR71-D	QR71	11/05/2001	SILICON	16900		9.9	UG/L		*
IS-QR71-D	QR71	11/05/2001	SODIUM	23500		15	UG/L		*
IS-QR71-D	QR71	11/05/2001	ALKALINITY	584		0.725	MG/L		*
IS-QR71-D	QR71	11/05/2001	URANIUM, TOTAL	0.939	0.0336	0.0744	PCI/L		*
IS-QR72-D	QR72	11/05/2001	CHLORIDE	11.7		0.025	MG/L		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
IS-QR72-D	QR72	11/05/2001	NITRATE-N	0.03		0.0069	MG/L		*
IS-QR72-D	QR72	11/05/2001	SULFATE	0.624		0.062	MG/L		*
IS-QR72-D	QR72	11/05/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR72-D	QR72	11/05/2001	CALCIUM	186000		24.7	UG/L		*
IS-QR72-D	QR72	11/05/2001	IRON	29100		2.24	UG/L		*
IS-QR72-D	QR72	11/05/2001	MAGNESIUM	53700		5.14	UG/L		*
IS-QR72-D	QR72	11/05/2001	MANGANESE	2140		0.369	UG/L		*
IS-QR72-D	QR72	11/05/2001	POTASSIUM	3800		18.2	UG/L		*
IS-QR72-D	QR72	11/05/2001	SILICON	26400		9.9	UG/L		*
IS-QR72-D	QR72	11/05/2001	SODIUM	29000		15	UG/L		*
IS-QR72-D	QR72	11/05/2001	ALKALINITY	688		0.725	MG/L	H0/26	*
IS-QR72-D	QR72	11/05/2001	URANIUM, TOTAL	5.42	0.115	0.0744	PCI/L		*
IS-QR73-D	QR73	11/05/2001	CHLORIDE	9.5		0.025	MG/L		*
IS-QR73-D	QR73	11/05/2001	NITRATE-N	0.02		0.0069	MG/L		*
IS-QR73-D	QR73	11/05/2001	SULFATE	22.7		0.062	MG/L		*
IS-QR73-D	QR73	11/05/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR73-D	QR73	11/05/2001	CALCIUM	173000		24.7	UG/L		*
IS-QR73-D	QR73	11/05/2001	IRON	22700		2.24	UG/L		*
IS-QR73-D	QR73	11/05/2001	MAGNESIUM	39200		5.14	UG/L		*
IS-QR73-D	QR73	11/05/2001	MANGANESE	3060		0.369	UG/L		*
IS-QR73-D	QR73	11/05/2001	POTASSIUM	3630		18.2	UG/L		*
IS-QR73-D	QR73	11/05/2001	SILICON	23000		9.9	UG/L		*
IS-QR73-D	QR73	11/05/2001	SODIUM	23400		15	UG/L		*
IS-QR73-D	QR73	11/05/2001	ALKALINITY	548		0.725	MG/L		*
IS-QR73-D	QR73	11/05/2001	URANIUM, TOTAL	3.04	0.0687	0.0744	PCI/L		*
IS-QR74-S	QR74	11/12/2001	URANIUM, TOTAL	4270	152	3.72	PCI/L		*
IS-QR75-S	QR75	11/12/2001	CHLORIDE	14.9		0.025	MG/L		*
IS-QR75-S	QR75	11/12/2001	NITRATE-N	0.00345		0.0069	MG/L		*
IS-QR75-S	QR75	11/12/2001	SULFATE	107		0.31	MG/L		*
IS-QR75-S	QR75	11/12/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR75-S	QR75	11/12/2001	CALCIUM	163000		24.7	UG/L		*
IS-QR75-S	QR75	11/12/2001	IRON	1.12		2.24	UG/L		*
IS-QR75-S	QR75	11/12/2001	MAGNESIUM	31800		5.14	UG/L		*
IS-QR75-S	QR75	11/12/2001	MANGANESE	135		0.369	UG/L		*
IS-QR75-S	QR75	11/12/2001	POTASSIUM	12100		18.2	UG/L		*
IS-QR75-S	QR75	11/12/2001	SILICON	12700		9.9	UG/L		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
IS-QR75-S	QR75	11/12/2001	SODIUM	30800		15	UG/L		*
IS-QR75-S	QR75	11/12/2001	ALKALINITY	485		0.725	MG/L		*
IS-QR75-S	QR75	11/12/2001	URANIUM, TOTAL	4590	162	3.72	PCI/L		*
IS-QR76-D	QR76	11/08/2001	CHLORIDE	17.9		0.025	MG/L		*
IS-QR76-D	QR76	11/08/2001	NITRATE-N	0.00345		0.0069	MG/L		*
IS-QR76-D	QR76	11/08/2001	SULFATE	43.6		0.062	MG/L		*
IS-QR76-D	QR76	11/08/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR76-D	QR76	11/08/2001	CALCIUM	175000		24.7	UG/L		*
IS-QR76-D	QR76	11/08/2001	IRON	18100		2.24	UG/L		*
IS-QR76-D	QR76	11/08/2001	MAGNESIUM	32400		5.14	UG/L		*
IS-QR76-D	QR76	11/08/2001	MANGANESE	2690		0.369	UG/L		*
IS-QR76-D	QR76	11/08/2001	POTASSIUM	4990		18.2	UG/L		*
IS-QR76-D	QR76	11/08/2001	SILICON	14500		9.9	UG/L		*
IS-QR76-D	QR76	11/08/2001	SODIUM	41000		15	UG/L		*
IS-QR76-D	QR76	11/08/2001	ALKALINITY	604		0.725	MG/L		*
IS-QR76-D	QR76	11/08/2001	URANIUM, TOTAL	516	18.2	0.149	PCI/L		*
IS-QR77-D	QR77	11/12/2001	CHLORIDE	9.11		0.025	MG/L		*
IS-QR77-S	QR77	12/03/2001	CHLORIDE	5.86		0.05	MG/L		*
IS-QR77-D	QR77	11/12/2001	NITRATE-N	0.00345		0.0069	MG/L		*
IS-QR77-S	QR77	12/03/2001	NITRATE-N	1.57		0.0069	MG/L		*
IS-QR77-D	QR77	11/12/2001	SULFATE	16.6		0.062	MG/L		*
IS-QR77-S	QR77	12/03/2001	SULFATE	84.9		0.124	MG/L		*
IS-QR77-D	QR77	11/12/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR77-S	QR77	12/03/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR77-D	QR77	11/12/2001	CALCIUM	162000		24.7	UG/L		*
IS-QR77-S	QR77	12/03/2001	CALCIUM	138000		24.7	UG/L		*
IS-QR77-D	QR77	11/12/2001	IRON	17000		2.24	UG/L		*
IS-QR77-S	QR77	12/03/2001	IRON	5.72		2.24	UG/L		*
IS-QR77-D	QR77	11/12/2001	MAGNESIUM	31900		5.14	UG/L		*
IS-QR77-S	QR77	12/03/2001	MAGNESIUM	24500		5.14	UG/L		*
IS-QR77-D	QR77	11/12/2001	MANGANESE	3720		0.369	UG/L		*
IS-QR77-S	QR77	12/03/2001	MANGANESE	74.2		0.369	UG/L		*
IS-QR77-D	QR77	11/12/2001	POTASSIUM	5200		18.2	UG/L		*
IS-QR77-S	QR77	12/03/2001	POTASSIUM	5780		18.2	UG/L		*
IS-QR77-D	QR77	11/12/2001	SILICON	13500		9.9	UG/L		*
IS-QR77-S	QR77	12/03/2001	SILICON	8650		9.9	UG/L		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
IS-QR77-D	QR77	11/12/2001	SODIUM	28500		15	UG/L		*
IS-QR77-S	QR77	12/03/2001	SODIUM	18200		15	UG/L		*
IS-QR77-D	QR77	11/12/2001	ALKALINITY	587		0.725	MG/L		*
IS-QR77-S	QR77	12/03/2001	ALKALINITY	383		1.45	MG/L		*
IS-QR77-D	QR77	11/12/2001	URANIUM, TOTAL	75.6	2.71	0.0744	PCI/L		*
IS-QR77-S	QR77	12/03/2001	URANIUM, TOTAL	2180	75.4	0.744	PCI/L		*
IS-QR79-S	QR79	11/20/2001	CHLORIDE	4.83		0.025	MG/L		*
IS-QR79-S	QR79	11/20/2001	NITRATE-N	0.03		0.0069	MG/L		*
IS-QR79-S	QR79	11/20/2001	SULFATE	125		0.31	MG/L		*
IS-QR79-S	QR79	11/20/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR79-S	QR79	11/20/2001	CALCIUM	155000		24.7	UG/L		*
IS-QR79-S	QR79	11/20/2001	IRON	1.12		2.24	UG/L		*
IS-QR79-S	QR79	11/20/2001	MAGNESIUM	28300		5.14	UG/L		*
IS-QR79-S	QR79	11/20/2001	MANGANESE	1.5		0.369	UG/L		*
IS-QR79-S	QR79	11/20/2001	POTASSIUM	1370		18.2	UG/L		*
IS-QR79-S	QR79	11/20/2001	SILICON	13400		9.9	UG/L		*
IS-QR79-S	QR79	11/20/2001	SODIUM	11500		15	UG/L		*
IS-QR79-S	QR79	11/20/2001	ALKALINITY	434		0.725	MG/L		*
IS-QR79-S	QR79	11/20/2001	URANIUM, TOTAL	76.1	2.68	0.0744	PCI/L		*
IS-QR80-D	QR80	11/20/2001	CHLORIDE	12		0.025	MG/L		*
IS-QR80-S	QR80	11/20/2001	CHLORIDE	5.36		0.025	MG/L		*
IS-QR80-D	QR80	11/20/2001	NITRATE-N	0.08		0.0069	MG/L		*
IS-QR80-S	QR80	11/20/2001	NITRATE-N	0.12		0.0069	MG/L		*
IS-QR80-S	QR80	11/20/2001	SULFATE	58.3		0.124	MG/L		*
IS-QR80-D	QR80	11/20/2001	SULFATE	120		0.31	MG/L		*
IS-QR80-D	QR80	11/20/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR80-S	QR80	11/20/2001	ALUMINUM	4.77		9.54	UG/L		*
IS-QR80-S	QR80	11/20/2001	CALCIUM	115000		24.7	UG/L		*
IS-QR80-D	QR80	11/20/2001	CALCIUM	166000		24.7	UG/L		*
IS-QR80-D	QR80	11/20/2001	IRON	793		2.24	UG/L		*
IS-QR80-S	QR80	11/20/2001	IRON	18.3		2.24	UG/L		*
IS-QR80-D	QR80	11/20/2001	MAGNESIUM	29800		5.14	UG/L		*
IS-QR80-S	QR80	11/20/2001	MAGNESIUM	22200		5.14	UG/L		*
IS-QR80-S	QR80	11/20/2001	MANGANESE	41.4		0.369	UG/L		*
IS-QR80-D	QR80	11/20/2001	MANGANESE	1250		0.369	UG/L		*
IS-QR80-S	QR80	11/20/2001	POTASSIUM	1620		18.2	UG/L		*

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IS-QR80-D	QR80	11/20/2001	POTASSIUM	4550		18.2	UG/L		*
IS-QR80-S	QR80	11/20/2001	SILICON	11700		9.9	UG/L		*
IS-QR80-D	QR80	11/20/2001	SILICON	18200		9.9	UG/L		*
IS-QR80-S	QR80	11/20/2001	SODIUM	12500		15	UG/L		*
IS-QR80-D	QR80	11/20/2001	SODIUM	25200		15	UG/L		*
IS-QR80-D	QR80	11/20/2001	ALKALINITY	464		0.725	MG/L		*
IS-QR80-S	QR80	11/20/2001	ALKALINITY	388		0.725	MG/L		*
IS-QR80-S	QR80	11/20/2001	URANIUM, TOTAL	21.2	0.776	0.0744	PCI/L		*
IS-QR80-D	QR80	11/20/2001	URANIUM, TOTAL	4.09	0.0676	0.0744	PCI/L		*

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WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
SO-100001-S	100001	10/26/2001	IRON	15600		1.36	UG/G		*
SO-100001-S	100001	10/26/2001	MANGANESE	407		0.18	UG/G		*
SO-100001-S	100001	10/26/2001	PERCENT MOISTURE	24.8		0.1	PRCNT		*
SO-100001-S	100001	10/26/2001	TOTAL ORGANIC CARBON	8260		33.2	UG/G		*
SO-100001-S	100001	10/26/2001	URANIUM-234	1.5	0.45	0.07	PCI/G		*
SO-100001-S	100001	10/26/2001	URANIUM-235	0.077	0.079	0.042	PCI/G		*
SO-100001-S	100001	10/26/2001	URANIUM-238	1.7	0.49	0.08	PCI/G		*
SO-100002-S	100002	10/26/2001	IRON	26000		1.36	UG/G		*
SO-100002-D	100002	10/26/2001	IRON	15800		1.36	UG/G		*
SO-100002-D	100002	10/26/2001	MANGANESE	569		0.18	UG/G		*
SO-100002-S	100002	10/26/2001	MANGANESE	344		0.18	UG/G		*
SO-100002-D	100002	10/26/2001	PERCENT MOISTURE	23.7		0.1	PRCNT		*
SO-100002-S	100002	10/26/2001	PERCENT MOISTURE	26.5		0.1	PRCNT		*
SO-100002-D	100002	10/26/2001	TOTAL ORGANIC CARBON	13600		32.8	UG/G		*
SO-100002-S	100002	10/26/2001	TOTAL ORGANIC CARBON	8110		34	UG/G		*
SO-100002-S	100002	10/26/2001	URANIUM-234	5.2	1.4	0.08	PCI/G		*
SO-100002-D	100002	10/26/2001	URANIUM-234	2.52	0.62	0.05	PCI/G		*
SO-100002-D	100002	10/26/2001	URANIUM-235	0.131	0.082	0.067	PCI/G		*
SO-100002-S	100002	10/26/2001	URANIUM-235	0.31	0.17	0.15	PCI/G		*
SO-100002-S	100002	10/26/2001	URANIUM-238	4.7	1.2	0.09	PCI/G		*
SO-100002-D	100002	10/26/2001	URANIUM-238	2.65	0.65	0.04	PCI/G		*
SO-100003-S	100003	10/25/2001	IRON	29400		1.36	UG/G		*
SO-100003-D	100003	10/25/2001	IRON	10400		1.36	UG/G		*
SO-100003-D	100003	10/25/2001	MANGANESE	239		0.18	UG/G		*
SO-100003-S	100003	10/25/2001	MANGANESE	657		0.18	UG/G		*
SO-100003-S	100003	10/25/2001	PERCENT MOISTURE	29.2		0.1	PRCNT		*
SO-100003-D	100003	10/25/2001	PERCENT MOISTURE	21		0.1	PRCNT		*
SO-100003-S	100003	10/25/2001	TOTAL ORGANIC CARBON	6140		35.3	UG/G		*
SO-100003-D	100003	10/25/2001	TOTAL ORGANIC CARBON	5630		31.6	UG/G		*
SO-100003-D	100003	10/25/2001	URANIUM-234	0.53	0.21	0.07	PCI/G		*
SO-100003-S	100003	10/25/2001	URANIUM-234	0.92	0.28	0.03	PCI/G		*
SO-100003-S	100003	10/25/2001	URANIUM-235	0.0325		0.065	PCI/G		*
SO-100003-D	100003	10/25/2001	URANIUM-235	0.06		0.12	PCI/G		*
SO-100003-S	100003	10/25/2001	URANIUM-238	0.99	0.3	0.07	PCI/G		*
SO-100003-D	100003	10/25/2001	URANIUM-238	0.52	0.21	0.07	PCI/G		*
SO-100004-S	100004	10/31/2001	IRON	10700		1.36	UG/G		*
SO-100004-S	100004	10/31/2001	MANGANESE	299		0.18	UG/G		*
SO-100004-S	100004	10/31/2001	PERCENT MOISTURE	19.3		0.1	PRCNT		*

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SO-100004-S	100004	10/31/2001	TOTAL ORGANIC CARBON	3190		31	UG/G		*
SO-100004-S	100004	10/31/2001	URANIUM-234	3.76	0.9	0.08	PCI/G		*
SO-100004-S	100004	10/31/2001	URANIUM-235	0.11	0.077	0.078	PCI/G		*
SO-100004-S	100004	10/31/2001	URANIUM-238	3.81	0.91	0.06	PCI/G		*
SO-100005-D	100005	11/01/2001	IRON	9600		1.36	UG/G		*
SO-100005-S	100005	11/01/2001	IRON	11400		1.36	UG/G		*
SO-100005-S	100005	11/01/2001	MANGANESE	292		0.18	UG/G		*
SO-100005-D	100005	11/01/2001	MANGANESE	262		0.18	UG/G		*
SO-100005-S	100005	11/01/2001	PERCENT MOISTURE	21		0.1	%		*
SO-100005-D	100005	11/01/2001	PERCENT MOISTURE	24.2		0.1	%		*
SO-100005-D	100005	11/01/2001	TOTAL ORGANIC CARBON	11400		33	UG/G		*
SO-100005-S	100005	11/01/2001	TOTAL ORGANIC CARBON	4830		31.6	UG/G		*
SO-100005-S	100005	11/01/2001	URANIUM-234	11.1	2.4	0.1	PCI/G		*
SO-100005-D	100005	11/01/2001	URANIUM-234	0.6	0.24	0.05	PCI/G		*
SO-100005-S	100005	11/01/2001	URANIUM-235	0.95	0.32	0.09	PCI/G		*
SO-100005-D	100005	11/01/2001	URANIUM-235	0.04	0.065	0.13	PCI/G		*
SO-100005-D	100005	11/01/2001	URANIUM-238	0.31	0.17	0.11	PCI/G		*
SO-100005-S	100005	11/01/2001	URANIUM-238	10.7	2.4	0.1	PCI/G		*
SO-100006-D	100006	11/01/2001	IRON	18200		1.36	UG/G		*
SO-100006-S	100006	11/01/2001	IRON	14000		1.36	UG/G		*
SO-100006-D	100006	11/01/2001	MANGANESE	1110		0.18	UG/G		*
SO-100006-S	100006	11/01/2001	MANGANESE	1370		0.18	UG/G		*
SO-100006-D	100006	11/01/2001	PERCENT MOISTURE	23.2		0.1	PRCNT		*
SO-100006-S	100006	11/01/2001	PERCENT MOISTURE	20.2		0.1	PRCNT		*
SO-100006-S	100006	11/01/2001	TOTAL ORGANIC CARBON	6020		31.3	UG/G		*
SO-100006-D	100006	11/01/2001	TOTAL ORGANIC CARBON	7900		32.5	UG/G		*
SO-100006-D	100006	11/01/2001	URANIUM-234	0.56	0.22	0.1	PCI/G		*
SO-100006-S	100006	11/01/2001	URANIUM-234	9.2	2.1	0.1	PCI/G		*
SO-100006-D	100006	11/01/2001	URANIUM-235	0.056	0.066	0.05	PCI/G		*
SO-100006-S	100006	11/01/2001	URANIUM-235	0.64	0.24	0.08	PCI/G		*
SO-100006-S	100006	11/01/2001	URANIUM-238	10	2.2	0.09	PCI/G		*
SO-100006-D	100006	11/01/2001	URANIUM-238	0.78	0.27	0.08	PCI/G		*
SO-100007-S	100007	11/05/2001	IRON	10300		1.36	UG/G		*
SO-100007-D	100007	11/05/2001	IRON	17700		1.36	UG/G		*
SO-100007-S	100007	11/05/2001	MANGANESE	421		0.18	UG/G		*
SO-100007-D	100007	11/05/2001	MANGANESE	777		0.18	UG/G		*
SO-100007-S	100007	11/05/2001	PERCENT MOISTURE	22.1		0.1	PRCNT		*
SO-100007-D	100007	11/05/2001	PERCENT MOISTURE	31.8		0.1	PRCNT		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
SO-100007-D	100007	11/05/2001	TOTAL ORGANIC CARBON	24200		36.6	UG/G	E	*
SO-100007-S	100007	11/05/2001	TOTAL ORGANIC CARBON	4940		32.1	UG/G		*
SO-100007-D	100007	11/05/2001	URANIUM-234	0.5	0.18	0.08	PCI/G		*
SO-100007-S	100007	11/05/2001	URANIUM-234	4.12	0.99	0.11	PCI/G		*
SO-100007-D	100007	11/05/2001	URANIUM-235	0.04	0.05	0.068	PCI/G		*
SO-100007-S	100007	11/05/2001	URANIUM-235	0.17	0.11	0.08	PCI/G		*
SO-100007-S	100007	11/05/2001	URANIUM-238	4.11	0.98	0.13	PCI/G		*
SO-100007-D	100007	11/05/2001	URANIUM-238	0.65	0.22	0.06	PCI/G		*
SO-100008-S	100008	11/07/2001	IRON	22800		1.7	UG/G		*
SO-100008-S	100008	11/07/2001	MANGANESE	410		0.22	UG/G		*
SO-100008-S	100008	11/07/2001	PERCENT MOISTURE	18.3		0.1	PRCNT		*
SO-100008-S	100008	11/07/2001	TOTAL ORGANIC CARBON	7960		30.6	UG/G		*
SO-100008-S	100008	11/07/2001	URANIUM-234	4.9	1.4	0.2	PCI/G		*
SO-100008-S	100008	11/07/2001	URANIUM-235	0.28	0.22	0.17	PCI/G		*
SO-100008-S	100008	11/07/2001	URANIUM-238	5	1.4	0.1	PCI/G		*
SO-100009-D	100009	11/05/2001	IRON	11900		1.36	UG/G		*
SO-100009-S	100009	11/05/2001	IRON	8380		1.36	UG/G		*
SO-100009-D	100009	11/05/2001	MANGANESE	363		0.18	UG/G		*
SO-100009-S	100009	11/05/2001	MANGANESE	121		0.18	UG/G		*
SO-100009-D	100009	11/05/2001	PERCENT MOISTURE	27.9		0.1	PRCNT		*
SO-100009-S	100009	11/05/2001	PERCENT MOISTURE	22.5		0.1	PRCNT		*
SO-100009-S	100009	11/05/2001	TOTAL ORGANIC CARBON	4130		32.3	UG/G		*
SO-100009-D	100009	11/05/2001	TOTAL ORGANIC CARBON	7780		34.7	UG/G		*
SO-100009-S	100009	11/05/2001	URANIUM-234	35.2	7.5	0.1	PCI/G		*
SO-100009-D	100009	11/05/2001	URANIUM-234	0.51	0.2	0.09	PCI/G		*
SO-100009-S	100009	11/05/2001	URANIUM-235	1.98	0.55	0.1	PCI/G		*
SO-100009-D	100009	11/05/2001	URANIUM-235	0.03	0.048	0.079	PCI/G		*
SO-100009-D	100009	11/05/2001	URANIUM-238	0.65	0.23	0.08	PCI/G		*
SO-100009-S	100009	11/05/2001	URANIUM-238	35	7.5	0.1	PCI/G		*
SO-100010-S	100010	11/05/2001	IRON	8230		1.36	UG/G		*
SO-100010-D	100010	11/05/2001	IRON	16700		1.36	UG/G		*
SO-100010-D	100010	11/05/2001	MANGANESE	581		0.18	UG/G		*
SO-100010-S	100010	11/05/2001	MANGANESE	204		0.18	UG/G		*
SO-100010-D	100010	11/05/2001	PERCENT MOISTURE	27.4		0.1	PRCNT		*
SO-100010-S	100010	11/05/2001	PERCENT MOISTURE	21.8		0.1	PRCNT		*
SO-100010-D	100010	11/05/2001	TOTAL ORGANIC CARBON	10900		34.4	UG/G		*
SO-100010-S	100010	11/05/2001	TOTAL ORGANIC CARBON	6760		32	UG/G		*
SO-100010-S	100010	11/05/2001	URANIUM-234	14.7	3.2	0.1	PCI/G		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
SO-100010-D	100010	11/05/2001	URANIUM-234	0.68	0.25	0.09	PCI/G		*
SO-100010-D	100010	11/05/2001	URANIUM-235	0.02	0.036	0.048	PCI/G		*
SO-100010-S	100010	11/05/2001	URANIUM-235	0.76	0.26	0.08	PCI/G		*
SO-100010-S	100010	11/05/2001	URANIUM-238	14.6	3.1	0.1	PCI/G		*
SO-100010-D	100010	11/05/2001	URANIUM-238	0.61	0.23	0.04	PCI/G		*
SO-100011-D	100011	11/05/2001	IRON	10500		1.36	UG/G		*
SO-100011-S	100011	11/05/2001	IRON	16100		1.36	UG/G		*
SO-100011-D	100011	11/05/2001	MANGANESE	301		0.18	UG/G		*
SO-100011-S	100011	11/05/2001	MANGANESE	287		0.18	UG/G		*
SO-100011-D	100011	11/05/2001	PERCENT MOISTURE	22.8		0.1	PRCNT		*
SO-100011-S	100011	11/05/2001	PERCENT MOISTURE	23		0.1	PRCNT		*
SO-100011-D	100011	11/05/2001	TOTAL ORGANIC CARBON	5900		32.4	UG/G		*
SO-100011-S	100011	11/05/2001	TOTAL ORGANIC CARBON	8460		32.5	UG/G		*
SO-100011-S	100011	11/05/2001	URANIUM-234	4.9	1.1	0.07	PCI/G		*
SO-100011-D	100011	11/05/2001	URANIUM-234	0.71	0.25	0.04	PCI/G		*
SO-100011-S	100011	11/05/2001	URANIUM-235	0.22	0.13	0.09	PCI/G		*
SO-100011-D	100011	11/05/2001	URANIUM-235	0.03	0.047	0.044	PCI/G		*
SO-100011-D	100011	11/05/2001	URANIUM-238	0.59	0.22	0.06	PCI/G		*
SO-100011-S	100011	11/05/2001	URANIUM-238	5.7	1.3	0.07	PCI/G		*
SO-100012-D	100012	11/07/2001	IRON	14600		1.8	UG/G		*
SO-100012-D	100012	11/07/2001	MANGANESE	140		0.23	UG/G		*
SO-100012-D	100012	11/07/2001	PERCENT MOISTURE	24.5		0.1	PRCNT		*
SO-100012-D	100012	11/07/2001	TOTAL ORGANIC CARBON	7460		33.1	UG/G		*
SO-100012-D	100012	11/07/2001	URANIUM-234	7	1.8	0.2	PCI/G		*
SO-100012-D	100012	11/07/2001	URANIUM-235	0.32	0.2	0.18	PCI/G		*
SO-100012-D	100012	11/07/2001	URANIUM-238	6.7	1.7	0.2	PCI/G		*
SO-100013-S	100013	11/08/2001	IRON	14400		1.8	UG/G		*
SO-100013-S	100013	11/08/2001	MANGANESE	131		0.23	UG/G		*
SO-100013-S1	100013	11/08/2001	PERCENT MOISTURE	28.8		0.1	PRCNT		*
SO-100013-S	100013	11/08/2001	PERCENT MOISTURE	22.5		0.1	PRCNT		*
SO-100013-S	100013	11/08/2001	TOTAL ORGANIC CARBON	6690		32.2	UG/G		*
SO-100013-S1	100013	11/08/2001	URANIUM-234	10.2	2.4	0.1	PCI/G		*
SO-100013-S	100013	11/08/2001	URANIUM-234	18.1	4.3	0.1	PCI/G		*
SO-100013-S	100013	11/08/2001	URANIUM-235	0.81	0.35	0.13	PCI/G		*
SO-100013-S1	100013	11/08/2001	URANIUM-235	0.59	0.25	0.14	PCI/G		*
SO-100013-S1	100013	11/08/2001	URANIUM-238	10.3	2.4	0.08	PCI/G		*
SO-100013-S	100013	11/08/2001	URANIUM-238	18.9	4.4	0.2	PCI/G		*
SO-100014-S	100014	11/08/2001	IRON	14900		1.8	UG/G		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
SO-100014-D	100014	11/08/2001	IRON	12100		1.8	UG/G		*
SO-100014-S	100014	11/08/2001	MANGANESE	497		0.23	UG/G		*
SO-100014-D	100014	11/08/2001	MANGANESE	348		0.24	UG/G		*
SO-100014-S	100014	11/08/2001	PERCENT MOISTURE	22.7		0.1	PRCNT		*
SO-100014-D	100014	11/08/2001	PERCENT MOISTURE	25.2		0.1	PRCNT		*
SO-100014-S	100014	11/08/2001	TOTAL ORGANIC CARBON	5510		32.3	UG/G		*
SO-100014-D	100014	11/08/2001	TOTAL ORGANIC CARBON	7490		33.4	UG/G		*
SO-100014-D	100014	11/08/2001	URANIUM-234	2.34	0.66	0.08	PCI/G		*
SO-100014-S	100014	11/08/2001	URANIUM-234	17.2	4.2	0.2	PCI/G		*
SO-100014-S	100014	11/08/2001	URANIUM-235	1.06	0.43	0.18	PCI/G		*
SO-100014-D	100014	11/08/2001	URANIUM-235	0.103	0.099	0.1	PCI/G		*
SO-100014-D	100014	11/08/2001	URANIUM-238	2.56	0.7	0.08	PCI/G		*
SO-100014-S	100014	11/08/2001	URANIUM-238	17.4	4.2	0.3	PCI/G		*
SO-100015-S	100015	11/07/2001	IRON	13600		1.8	UG/G		*
SO-100015-D	100015	11/07/2001	IRON	13500		1.8	UG/G		*
SO-100015-S	100015	11/07/2001	MANGANESE	305		0.23	UG/G		*
SO-100015-D	100015	11/07/2001	MANGANESE	357		0.23	UG/G		*
SO-100015-D1	100015	11/07/2001	PERCENT MOISTURE	21.8		0.1	PRCNT		*
SO-100015-D5	100015	11/07/2001	PERCENT MOISTURE	25.6		0.1	PRCNT		*
SO-100015-S	100015	11/07/2001	PERCENT MOISTURE	23.7		0.1	PRCNT		*
SO-100015-D	100015	11/07/2001	PERCENT MOISTURE	22.1		0.1	PRCNT		*
SO-100015-D2	100015	11/07/2001	PERCENT MOISTURE	22.4		0.1	PRCNT		*
SO-100015-D3	100015	11/07/2001	PERCENT MOISTURE	22.7		0.1	PRCNT		*
SO-100015-D4	100015	11/07/2001	PERCENT MOISTURE	23.6		0.1	PRCNT		*
SO-100015-S	100015	11/07/2001	TOTAL ORGANIC CARBON	5530		32.8	UG/G		*
SO-100015-D	100015	11/07/2001	TOTAL ORGANIC CARBON	7120		32.1	UG/G		*
SO-100015-D5	100015	11/07/2001	URANIUM-234	87	23	0.1	PCI/G		*
SO-100015-D2	100015	11/07/2001	URANIUM-234	0.8	0.31	0.15	PCI/G		*
SO-100015-D4	100015	11/07/2001	URANIUM-234	0.88	0.35	0.23	PCI/G		*
SO-100015-D3	100015	11/07/2001	URANIUM-234	0.52	0.29	0.24	PCI/G		*
SO-100015-D1	100015	11/07/2001	URANIUM-234	1.25	0.42	0.09	PCI/G		*
SO-100015-D	100015	11/07/2001	URANIUM-234	1.35	0.42	0.05	PCI/G		*
SO-100015-S	100015	11/07/2001	URANIUM-234	14.9	3.6	0.1	PCI/G		*
SO-100015-D	100015	11/07/2001	URANIUM-235	0.04	0.059	0.056	PCI/G		*
SO-100015-D5	100015	11/07/2001	URANIUM-235	4.7	1.5	0.1	PCI/G		*
SO-100015-D1	100015	11/07/2001	URANIUM-235	0.13	0.12	0.14	PCI/G		*
SO-100015-D4	100015	11/07/2001	URANIUM-235	0.12	0.14	0.26	PCI/G		*
SO-100015-S	100015	11/07/2001	URANIUM-235	0.83	0.36	0.19	PCI/G		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
SO-100015-D2	100015	11/07/2001	URANIUM-235	0.02	0.048	0.11	PCI/G		*
SO-100015-D3	100015	11/07/2001	URANIUM-235	0.085		0.17	PCI/G		*
SO-100015-D5	100015	11/07/2001	URANIUM-238	86	22	0.3	PCI/G		*
SO-100015-S	100015	11/07/2001	URANIUM-238	15.3	3.7	0.06	PCI/G		*
SO-100015-D3	100015	11/07/2001	URANIUM-238	0.7	0.34	0.14	PCI/G		*
SO-100015-D4	100015	11/07/2001	URANIUM-238	0.73	0.3	0.1	PCI/G		*
SO-100015-D2	100015	11/07/2001	URANIUM-238	0.81	0.31	0.09	PCI/G		*
SO-100015-D	100015	11/07/2001	URANIUM-238	1.35	0.42	0.08	PCI/G		*
SO-100015-D1	100015	11/07/2001	URANIUM-238	1.09	0.38	0.11	PCI/G		*
SO-100017-S	100017	11/14/2001	IRON	20400		1.8	UG/G		*
SO-100017-S	100017	11/14/2001	MANGANESE	537		0.24	UG/G		*
SO-100017-S	100017	11/14/2001	PERCENT MOISTURE	25.8		0.1	PRCNT		*
SO-100017-S	100017	11/14/2001	TOTAL ORGANIC CARBON	8610		33.7	UG/G		*
SO-100017-S	100017	11/14/2001	URANIUM-234	1.08	0.42	0.19	PCI/G		*
SO-100017-S	100017	11/14/2001	URANIUM-235	0.03	0.066	0.16	PCI/G		*
SO-100017-S	100017	11/14/2001	URANIUM-238	0.99	0.4	0.13	PCI/G		*
SO-100018-D	100018	11/13/2001	IRON	14000		1.8	UG/G		*
SO-100018-S	100018	11/13/2001	IRON	15400		1.8	UG/G		*
SO-100018-S	100018	11/13/2001	MANGANESE	500		0.23	UG/G		*
SO-100018-D	100018	11/13/2001	MANGANESE	429		0.24	UG/G		*
SO-100018-D	100018	11/13/2001	PERCENT MOISTURE	25		0.1	PRCNT		*
SO-100018-S	100018	11/13/2001	PERCENT MOISTURE	23.4		0.1	PRCNT		*
SO-100018-S	100018	11/13/2001	TOTAL ORGANIC CARBON	9270		32.6	UG/G		*
SO-100018-D	100018	11/13/2001	TOTAL ORGANIC CARBON	14400		33.3	UG/G		*
SO-100018-D	100018	11/13/2001	URANIUM-234	0.79	0.3	0.09	PCI/G		*
SO-100018-S	100018	11/13/2001	URANIUM-234	0.76	0.27	0.07	PCI/G		*
SO-100018-D	100018	11/13/2001	URANIUM-235	0.06	0.083	0.13	PCI/G		*
SO-100018-S	100018	11/13/2001	URANIUM-235	0.05		0.1	PCI/G		*
SO-100018-S	100018	11/13/2001	URANIUM-238	0.88	0.3	0.08	PCI/G		*
SO-100018-D	100018	11/13/2001	URANIUM-238	1.06	0.37	0.17	PCI/G		*
SO-100019	100019	11/16/2001	IRON	4010		1.36	UG/G		*
SO-100019	100019	11/16/2001	MANGANESE	315		0.18	UG/G		*
SO-100019	100019	11/16/2001	PERCENT MOISTURE	1.1		0.1	PRCNT		*
SO-100019	100019	11/16/2001	URANIUM-234	0.393	0.106	0.077	PCI/G		*
SO-100019	100019	11/16/2001	URANIUM-235	0.062	0.057	0.077	PCI/G		*
SO-100019	100019	11/16/2001	URANIUM-238	0.365	0.109	0.1	PCI/G		*
SO-100019	100019	11/16/2001	URANIUM-238 (GAMMA)	0.2465		0.493	PCI/G		*
SO-100020	100020	11/19/2001	IRON	3830		1.36	UG/G		*

WSSRAP ID	LOCATION	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier
SO-100020	100020	11/19/2001	MANGANESE	347		0.18	UG/G		*
SO-100020	100020	11/19/2001	PERCENT MOISTURE	0.44		0.1	PRCNT		*
SO-100020	100020	11/19/2001	URANIUM-234	0.323	0.118	0.139	PCI/G		*
SO-100020	100020	11/19/2001	URANIUM-235	0.037	0.045	0.063	PCI/G		*
SO-100020	100020	11/19/2001	URANIUM-238	0.171	0.081	0.091	PCI/G		*
SO-100020	100020	11/19/2001	URANIUM-238 (GAMMA)	0.701	0.292	0.921	PCI/G		*

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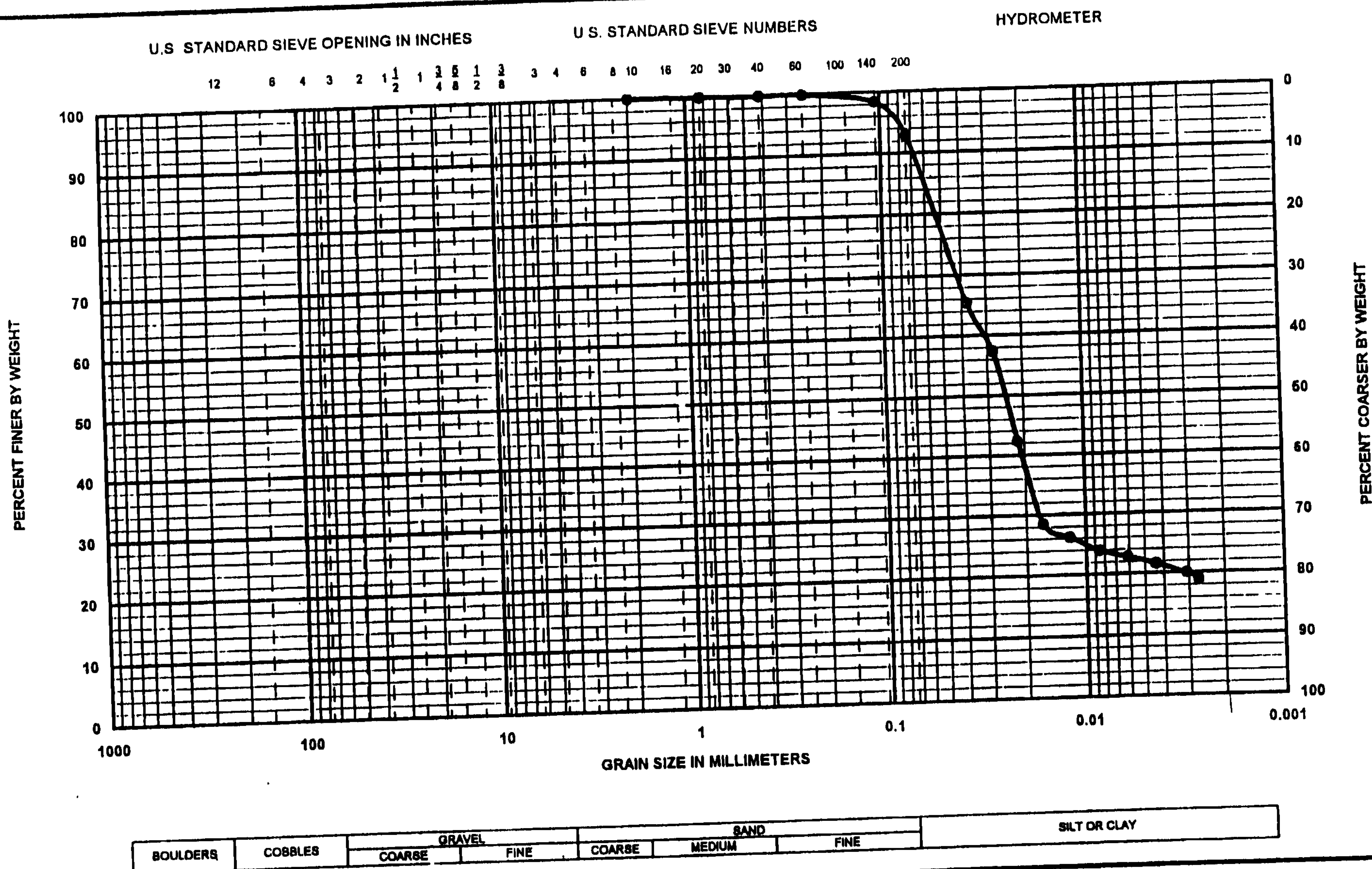
GRADATION CURVES

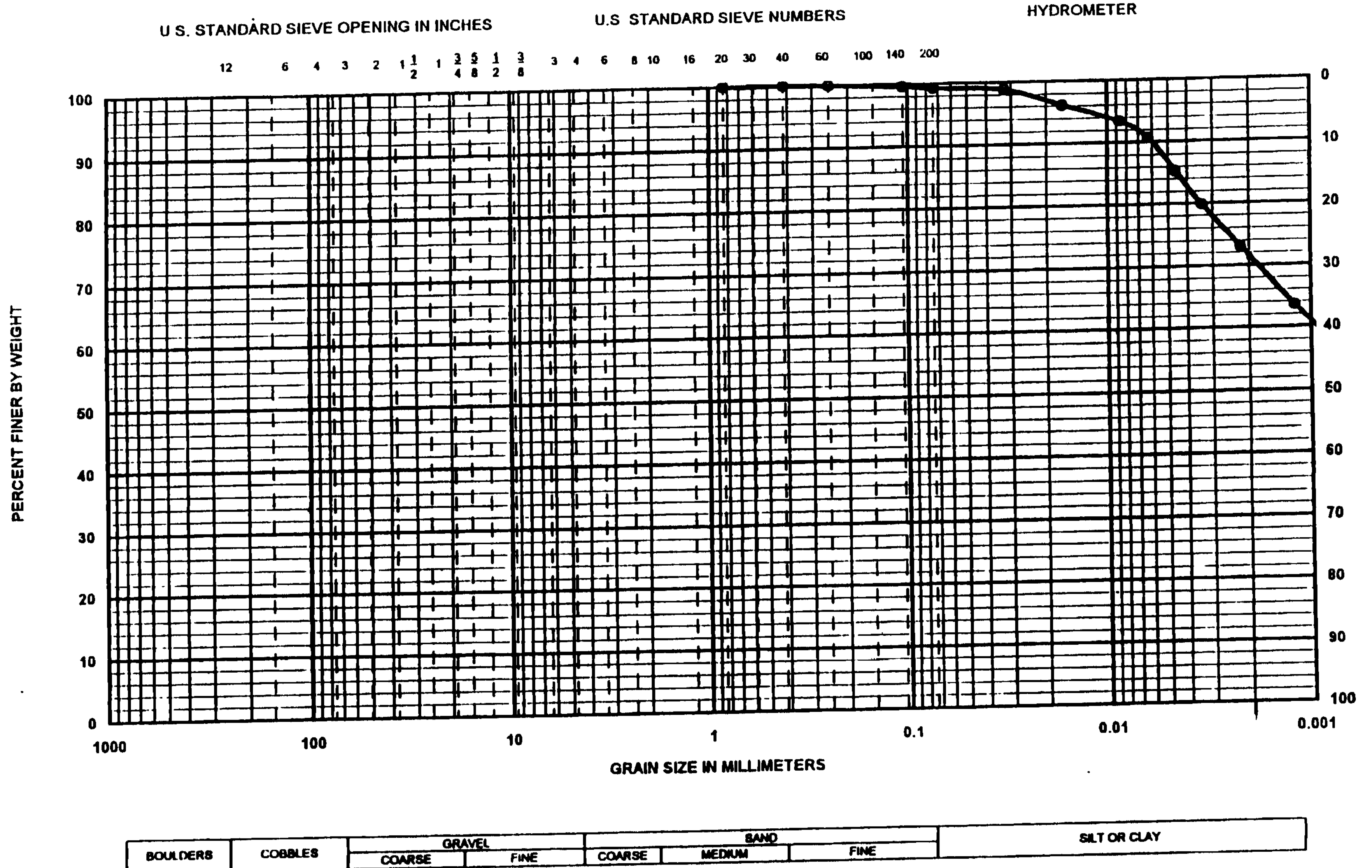


BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT. WT. %	LL	PL	PI
	QRSB-63ST						

PROJECT	WP-533 Task 2
JOB NO	0534001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

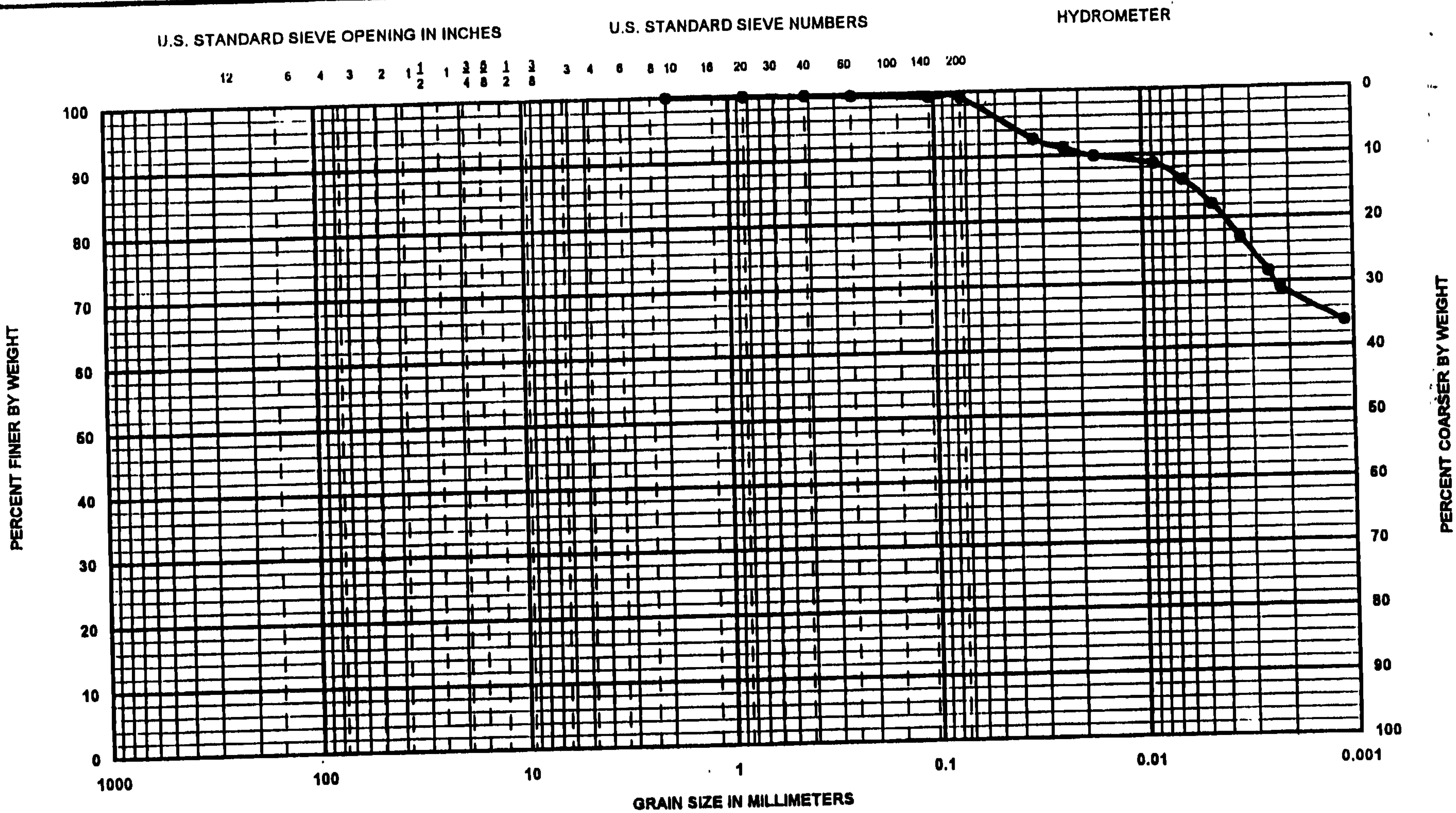
GRADATION CURVES



BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT WT %	LL	PL	PI	PROJECT	WP-533 Task 2
	QRSB-64ST							JOB NO	0534001 1153
								DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES



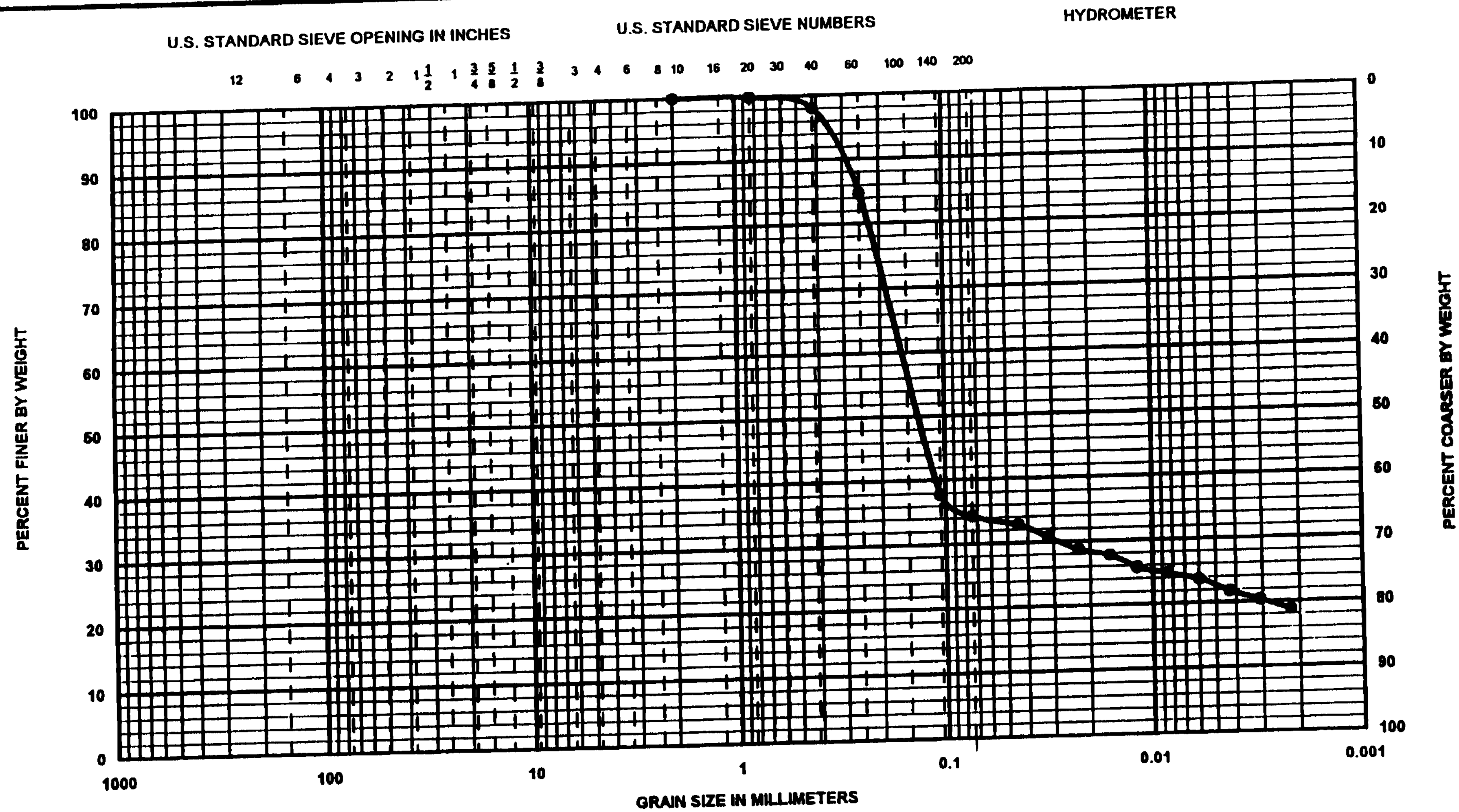
BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT WT. %	LL	PL	PI
	QRSB-65ST						

PROJECT	WP-533 Task 2
JOB NO	0534001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES



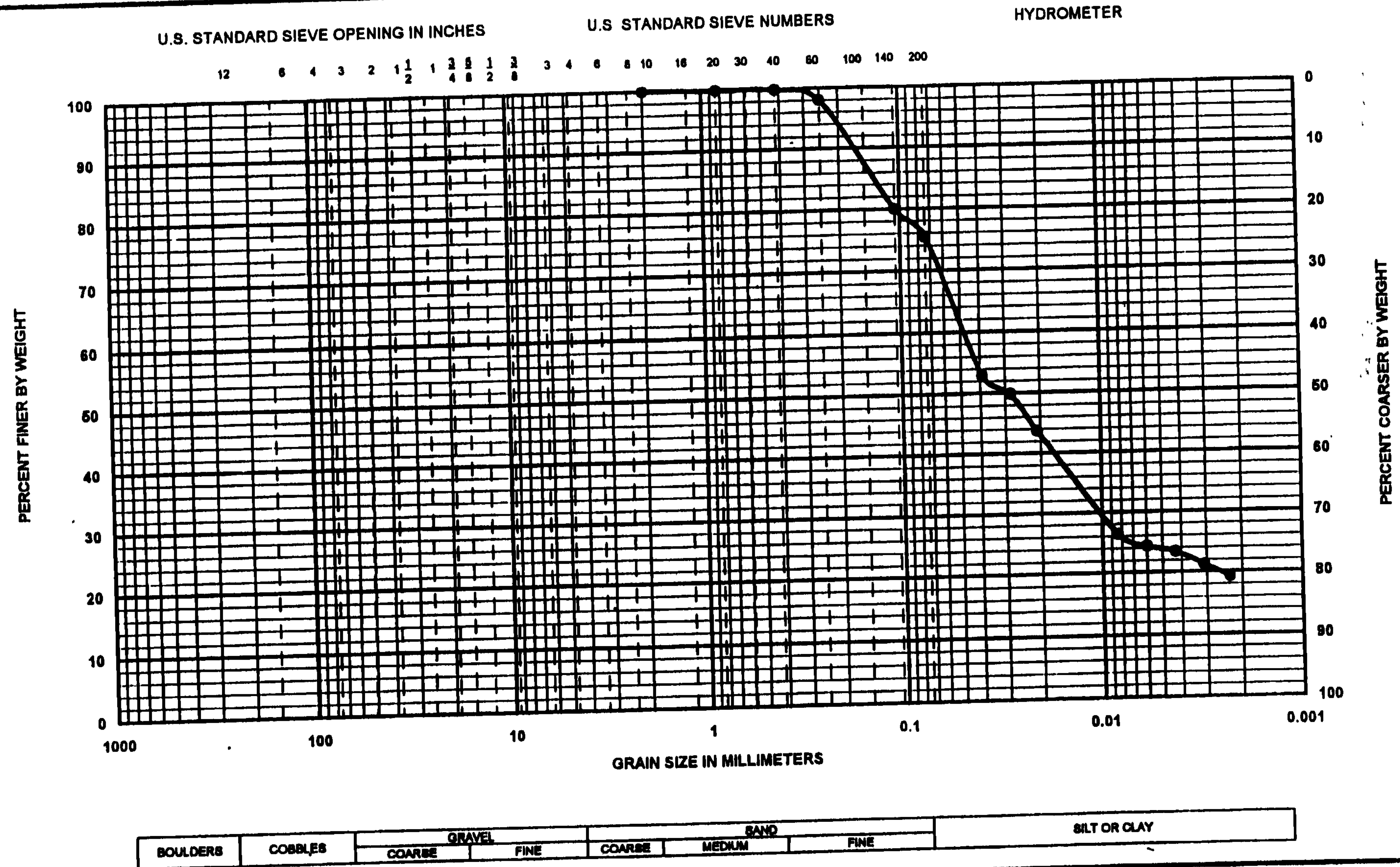
BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT. WT %	LL	PL	PI
	QRSB-66ST						

PROJECT	WP-533 Task 2
JOB NO	0534001 1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES

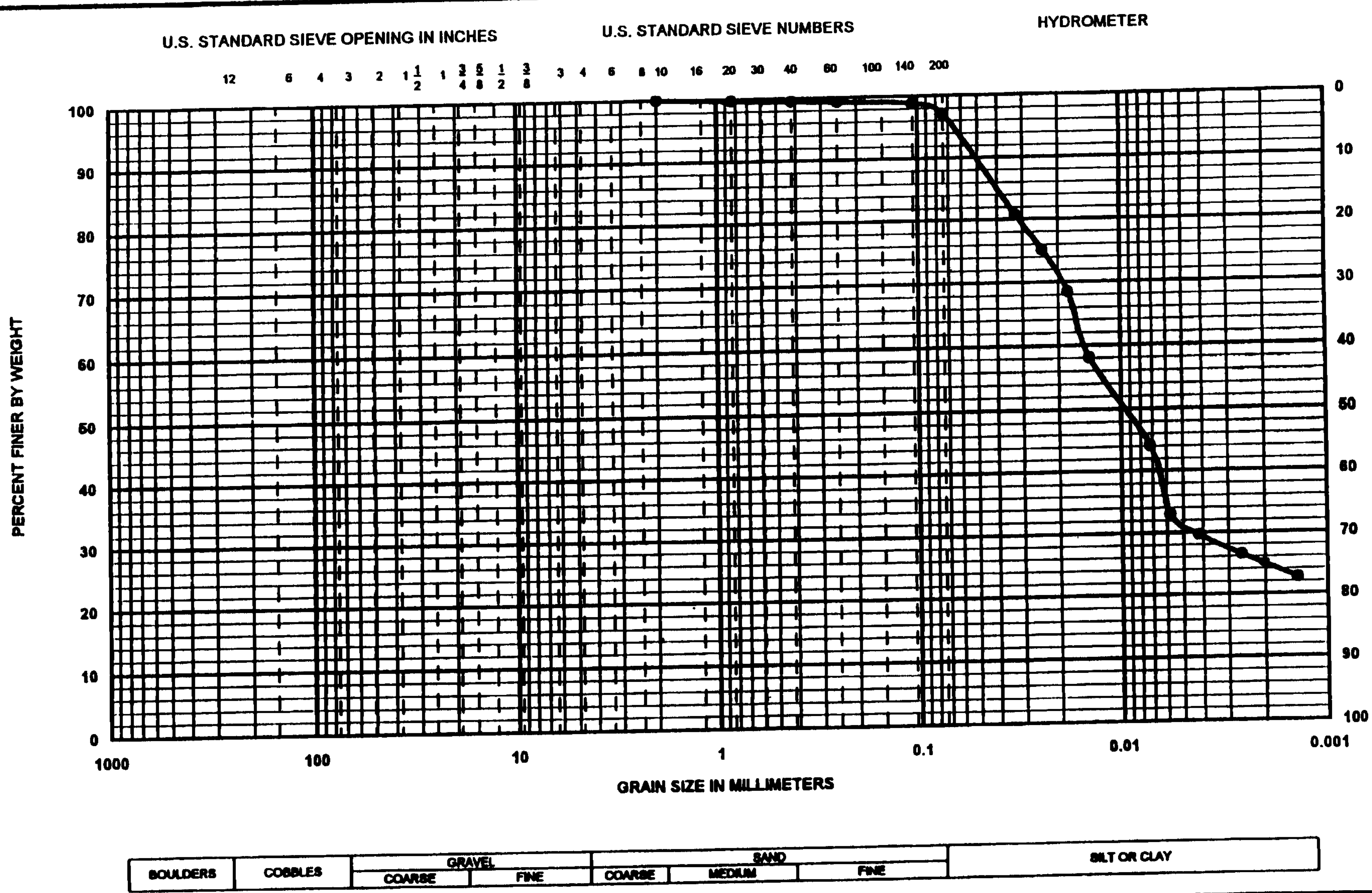


BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT WT. %	LL	PL	PI
	QRSB-67ST						

PROJECT	WP-533 Task 2
JOB NO	0534001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES

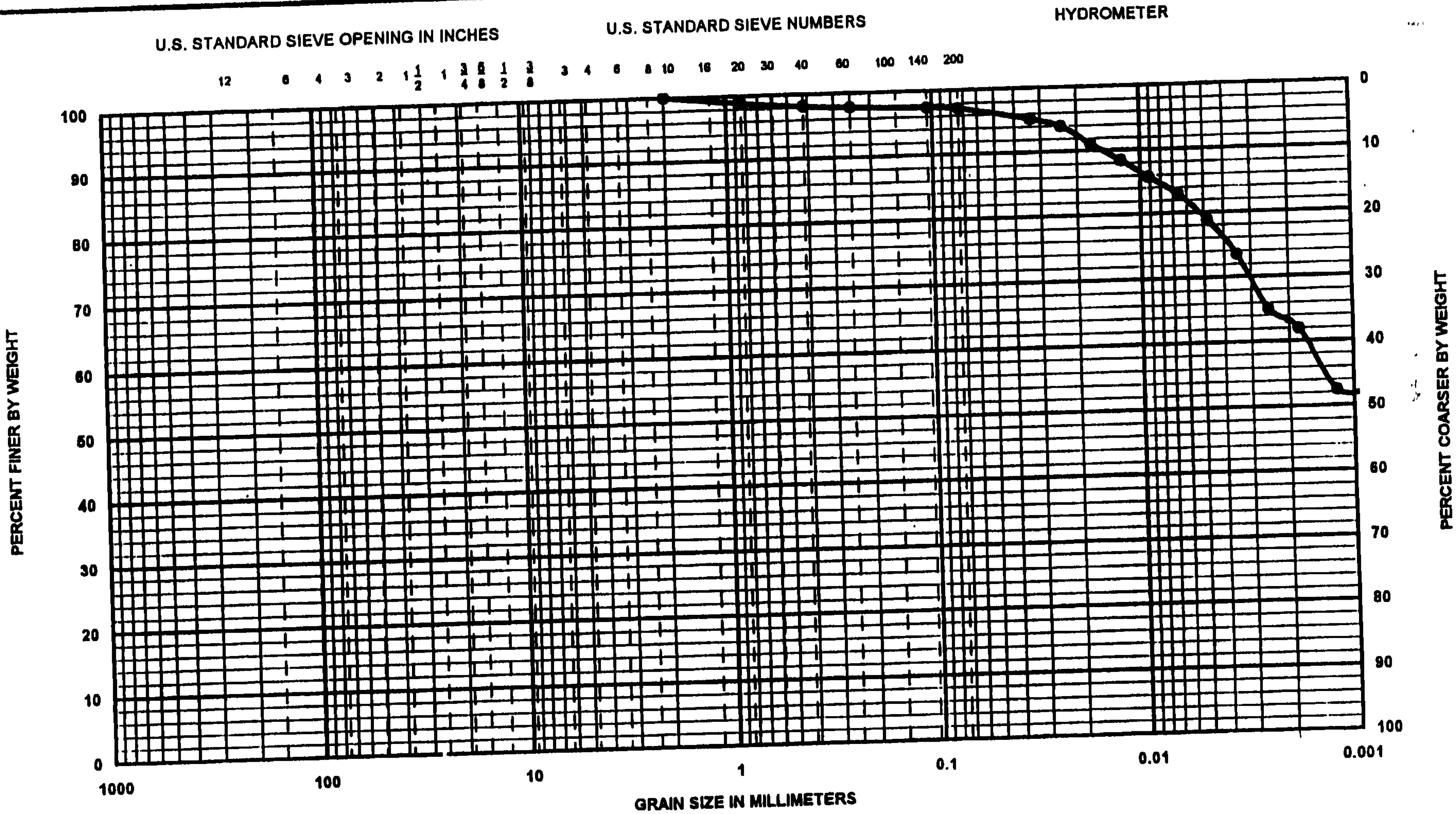


BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT. WT. %	LL	PL	PI
	QRSB-72ST						

PROJECT	WP-533 Task 2
JOB NO	0534001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES



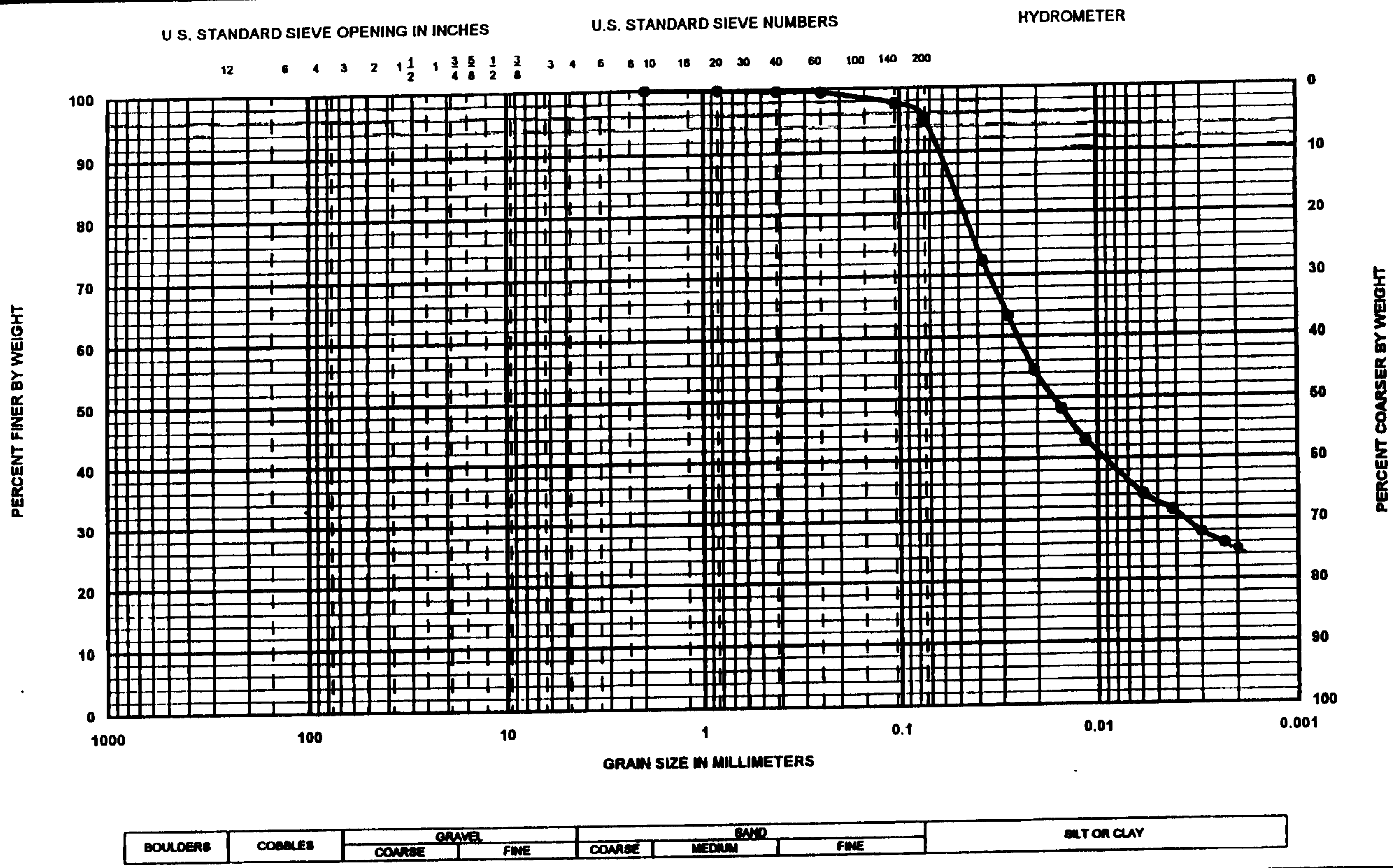
BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT. WT. %	LL	PL	PI
	QRSB-74ST						

PROJECT	WP-533 Task 2
JOB NO	0534001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES

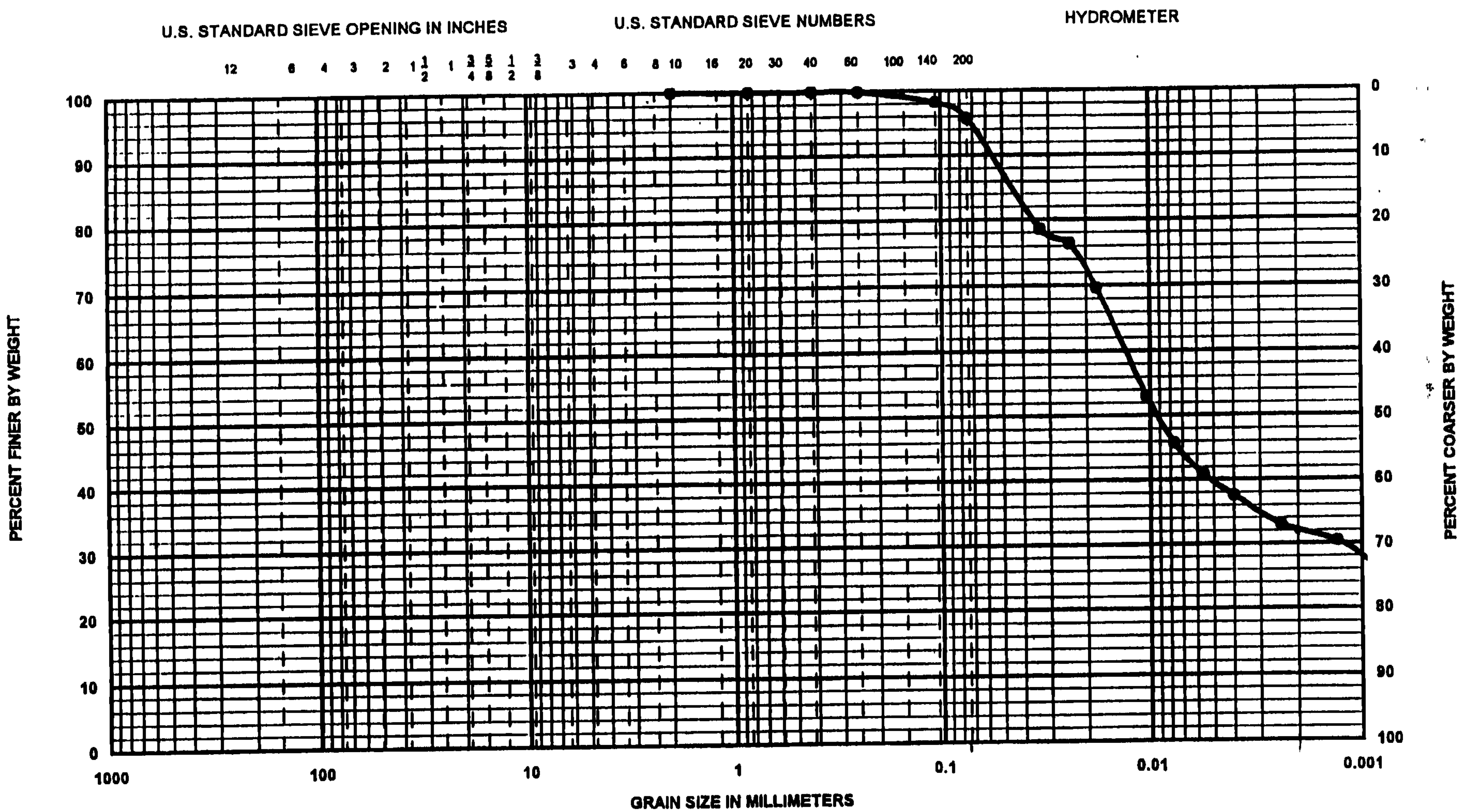


BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT WT. %	LL	PL	PI
	QRSB-75ST						

PROJECT	WP-533 Task 2
JOB NO	0534001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES



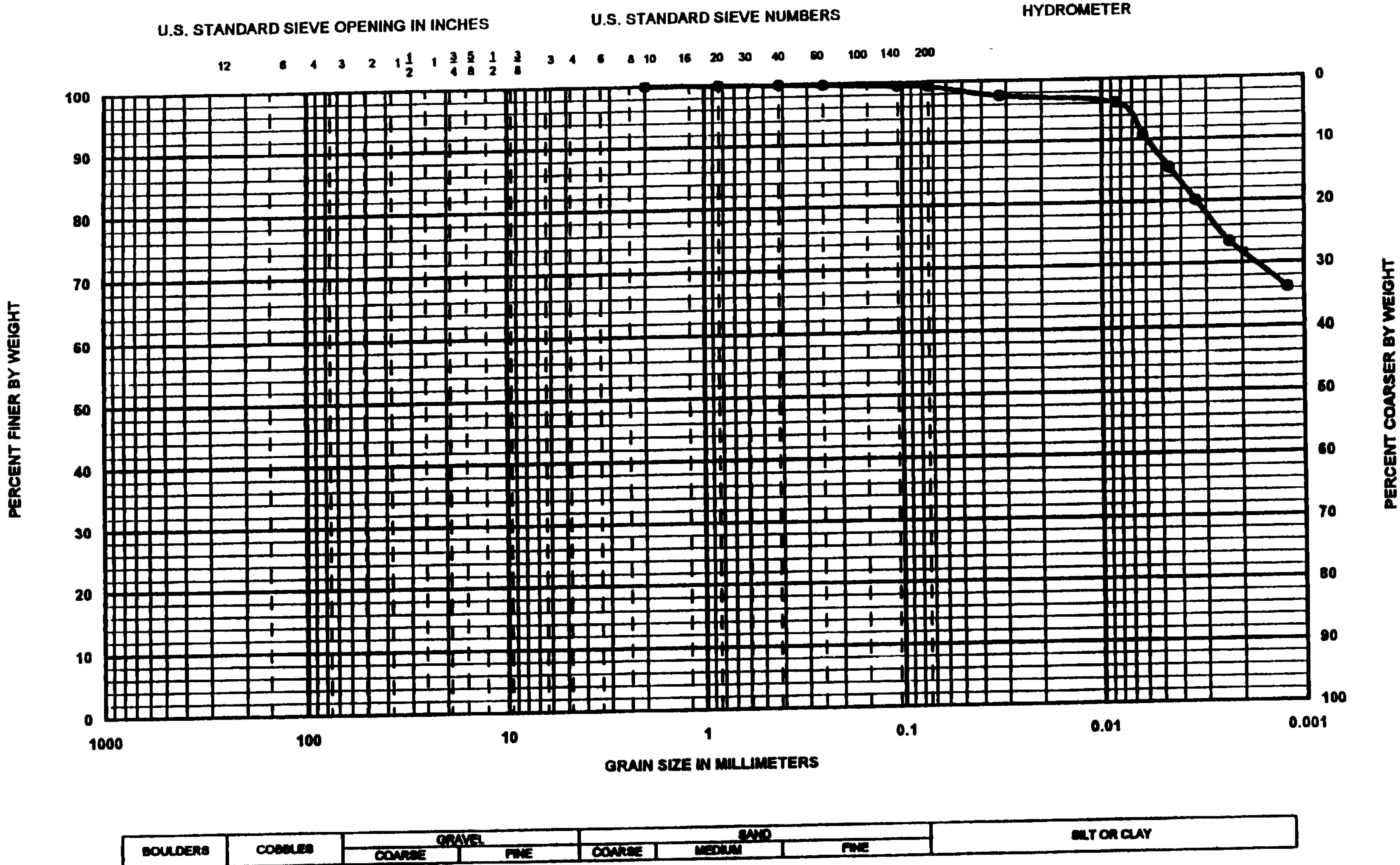
BOULDERS	COBBLES	GRAVEL		SAND			SILT OR CLAY
		COARSE	FINE	COARSE	MEDIUM	FINE	

BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT. WT. %	LL	PL	PI
	QRSB-79ST						

PROJECT	WP-533 Task 2
JOB NO	0534001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

GRADATION CURVES



BORING NO	SAMPLE NO	DEPTH (FT)	DESCRIPTION	NAT. WT. %	LL	PL	PI
	QRSB-80ST						

PROJECT	WP-633 Task 2
JOB NO	0634001.1153
DATE	11/16/2001

GEOTECHNOLOGY, INC.

Boring No. QRSB-63ST
Sample No.
Depth 9½-12 ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (in.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name WP-533 Task 2
Test Date 11-16-01
Tested By DEB
Calculated By KM
Checked By KF

Depth Feet	NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
				23" Feet Recovery Sample: Good Fair Poor Disturbed
9½ γ			PP=2.5 TV=.800	Very stiff sandy clay
Combo				AA
10½ Save				AA
			PP=.50 TV=.300	soft brown/gray sandy clay
11½				
12				

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt. + Tare			
Dry Wt. + Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content %			

(CONTINUED ON REVERSE SIDE)

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UNCONFINED COMPRESSION TEST AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.875	(in.)		(cm)
Height	5.982	(in.)		(cm)
Area		(in^2)		(cm^2)
Volume		(ft^3)		(cm^3)
Wet Weight		(lbs)	1166	(gm)
Wet Density	114	(pcf)		(Kg/cm^3)
Dry Density	85	(pcf)		(Kg/cm^3)

WATER CONTENT	
Tare No.	E-11
Wet Wt. + Tare	1325
Dry Wt. + Tare	1021
Wt. of Water	
Tare Wt.	159
Wt. of Dry Soil	
Water Content, %	35

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ____________

Failure Strain (%) ____________

Compression Strength, q u (tsf) ________

Undrained Shear Strength, S u (tsf) _____

FAILURE

REMARKS: ____________

Boring No. QRSO-64ST
Sample No.
Depth 12-14 ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (in.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name WP-533 Tank 2
Test Date 11-16-01
Tested By DEB
Calculated By KKO
Checked By KF

Depth Feet	NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
				19" Feet Recovery Sample: Good Fair Poor Disturbed
12 hydro.			PP=1.5 TV=.1800	brown/gray clay-CH
γ				AA
13 save			PP=1.0 TV=.450	AA
14				

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt.+Tare			
Dry Wt.+Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content%			

(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.875	(in.)		(cm)
Height	5.920	(in.)		(cm)
Area		(in^2)		(cm^2)
Volume		(ft^3)		(cm^3)
Wet Weight		(lbs)	1129	(gm)
Wet Density	112.	(pcf)		(Kg/cm^3)
Dry Density	80	(pcf)		(Kg/cm^3)

WATER CONTENT	
Tare No.	C-20
Wet Wt. + Tare	1324
Dry Wt. + Tare	1006
Wt. of Water	
Tare Wt.	195
Wt. of Dry Soil	
Water Content, %	39

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ____________

Failure Strain (%) ____________

Compression Strength, q u (tsf) ________

Undrained Shear Strength, S u (tsf) _____

FAILURE

REMARKS: ________________

Boring No. QRSB-65ST
Sample No.
Depth 11-13' ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (in.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name WP-533 Task 2
Test Date 11-16-01
Tested By DEB
Calculated By [illegible]
Checked By KF

Depth Feet	NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
				15 1/2" Feet Recovery Sample: Good Fair Poor Disturbed
11			PP=3.25 TV=.800	STIFF BROWN SILTY CLAY
γ				BROWN CLAY med. STIFF BROWN CLAY
12 hydro			PP=1.0 TV=.500	
13				

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt.+Tare			
Dry Wt.+Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content%			

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(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.870	(in.)		(cm)
Height	5.540	(in.)		(cm)
Area		(in²)		(cm²)
Volume		(ft³)		(cm³)
Wet Weight		(lbs)	1046	(gm)
Wet Density	111	(pcf)		(Kg/cm³)
Dry Density	78	(pcf)		(Kg/cm³)

WATER CONTENT	
Tare No.	E-4
Wet Wt. + Tare	1198
Dry Wt. + Tare	885
Wt. of Water	
Tare Wt.	152
Wt. of Dry Soil	
Water Content, %	43

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ________

Failure Strain (%) ________

Compression Strength, q u (tsf) ________

Undrained Shear Strength, S u (tsf) ________

FAILURE

REMARKS: ________

Boring No. QRSB-669T
Sample No. ~~9-3~~
Depth 9½-11½ ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (in.) 3"

GEOTECHNOLOGY

ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name WP-533 Task 2
Test Date 11-16-01
Tested By DEB
Calculated By KPD
Checked By KF

Depth Feet	NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
				12" Feet Recovery Sample: Good Fair Poor Disturbed
9½ combo			PP=/ TV=/	Brown clayey sand ↓
MC ~~*NOT-DISTURBED~~	C-25			
10½ save				
11½				

NATURAL WATER CONTENT DETERMINATIONS

Tare No.	C-25		
Wet Wt. + Tare	682		
Dry Wt. + Tare	624		
Wt. of Water			
Tare Wt.	195		
Wt. of Dry Soil			
Water Content %	14		

(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST
AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN			
Diameter	(in.)		(cm)
Height	(in.)		(cm)
Area	(in²)		(cm²)
Volume	(ft³)		(cm³)
Wet Weight	(lbs)		(gm)
Wet Density	(pcf)		(Kg/cm³)
Dry Density	(pcf)		(Kg/cm³)

WATER CONTENT	
Tare No.	
Wet Wt. + Tare	
Dry Wt. + Tare	
Wt. of Water	
Tare Wt.	
Wt. of Dry Soil	
Water Content, %	

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ____________

Failure Strain (%) ____________

Compression Strength, q u (tsf) ________

Undrained Shear Strength, S u (tsf) _____

FAILURE

REMARKS: ____________________

Boring No. QRSB-67ST

Sample No.

Depth 10-12 ft.

Sampling Method

Type of Sample Shelby Tube

Outside Diameter (in.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153

Job Name W. 537 Task 2

Test Date 11-16-01

Tested By DEB

Calculated By KAD

Checked By KF

Depth Feet		NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
					17" Feet Recovery Sample: Good Fair Poor Disturbed
10	combo			PP=1.0 TV=.250	med. stiff brown sandy clay
	✓				AA
11				PP=1.0 TV=.250	AA
12					

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt. + Tare			
Dry Wt. + Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content %			

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(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST
AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.880	(in.)		(cm)
Height	5.972	(in.)		(cm)
Area		(in²)		(cm²)
Volume		(ft³)		(cm³)
Wet Weight		(lbs)	1193	(gm)
Wet Density	117	(pcf)		(Kg/cm³)
Dry Density	90	(pcf)		(Kg/cm³)

WATER CONTENT	
Tare No.	05
Wet Wt. + Tare	1391
Dry Wt. + Tare	1117
Wt. of Water	
Tare Wt.	198
Wt. of Dry Soil	
Water Content, %	30

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ________

Failure Strain (%) ________

Compression Strength, q u (tsf) ________

Undrained Shear Strength, S u (tsf) ________

FAILURE

REMARKS:________

Boring No. QLSB-72ST
Sample No.
Depth 8½-9½ ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (In.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name WP-533 Task 2
Test Date 11-16-01
Tested By DEB
Calculated By KAM
Checked By KF

Depth Feet	NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
				12½" Feet Recovery Sample: Good Fair Poor Disturbed
8 combo. hydro			PP= / TV= /	Lt. brown sand brown clay w/ fine sand
γ				brown silty clay w/ sand
9			PP= 1.0 TV= .050	
10				

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt. + Tare			
Dry Wt. + Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content %			

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(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.870	(in.)		(cm)
Height	5.422	(in.)		(cm)
Area		(in²)		(cm²)
Volume		(ft³)		(cm³)
Wet Weight		(lbs)	1072	(gm)
Wet Density	116	(pcf)		(Kg/cm³)
Dry Density	89	(pcf)		(Kg/cm³)

WATER CONTENT	
Tare No.	XA-2
Wet Wt. + Tare	1230
Dry Wt. + Tare	977
Wt. of Water	
Tare Wt.	158
Wt. of Dry Soil	
Water Content, %	31

☐ Load Cell ☐ Proving . Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ____________

Failure Strain (%) ____________

Compression Strength, q u (tsf) ____________

Undrained Shear Strength, S u (tsf) ______

FAILURE

REMARKS: ____________

Boring No. QRSB-74 ST

Sample No.

Depth 9½-12 ft.

Sampling Method

Type of Sample Shelby Tube

Outside Diameter (in.) 3"

GEOTECHNOLOGY

ENGINEERING AND ENVIRONMENTAL SERVICES

SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.~~[illegible]~~1153

Job Name WP-533 Task 2

Test Date 11-16-01

Tested By DEB

Calculated By KAG

Checked By KF

Depth Feet		NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
					17" Feet Recovery Sample: Good Fair Poor Disturbed
9½	hydro			PP=1.75 TV=1.00	brown & gray clay-CH
	γ				AA
10½	Save				AA brown/gray clayey sand
11½					
12					

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt. + Tare			
Dry Wt. + Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content %			

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(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST
AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.875	(in.)		(cm)
Height	4.682	(in.)		(cm)
Area		(in²)		(cm²)
Volume		(ft³)		(cm³)
Wet Weight		(lbs)	904	(gm)
Wet Density	113	(pcf)		(Kg/cm³)
Dry Density	83	(pcf)		(Kg/cm³)

WATER CONTENT	
Tare No.	16
Wet Wt. + Tare	992
Dry Wt. + Tare	746
Wt. of Water	
Tare Wt.	88
Wt. of Dry Soil	
Water Content, %	37

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ________

Failure Strain (%) ________

Compression Strength, q u (tsf) ________

Undrained Shear Strength, S u (tsf) ________

FAILURE

REMARKS: ________

Boring No. QRSB-755T
Sample No.
Depth 10-12½ ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (in.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name WP-533 Task 2
Test Date 11-16-01
Tested By DEB
Calculated By KRD
Checked By KF

Depth Feet		NAT. W.C. Tare No.	W.C.	Type of Test	VISUAL CLASSIFICATION
					20" Feet Recovery Sample: Good Fair Poor Disturbed
10	Save			PP=1.0 TV=.300	gray/brown sandy clay
	Combo				gray/brown sandy clay
11	Y				gray/brown sandy clay
				PP=1.5 TV=.450	
12					
12½					

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt. + Tare			
Dry Wt. + Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content %			

F:\LABPROG\FORMS\LAB061.EKP

(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.870	(in.)		(cm)
Height	5.430	(in.)		(cm)
Area		(in^2)		(cm^2)
Volume		(ft^3)		(cm^3)
Wet Weight		(lbs)	1073	(gm)
Wet Density	116	(pcf)		(Kg/cm^3)
Dry Density	88	(pcf)		(Kg/cm^3)

WATER CONTENT	
Tare No.	C-9
Wet Wt. + Tare	1268
Dry Wt. + Tare	1004
Wt. of Water	
Tare Wt.	195
Wt. of Dry Soil	
Water Content, %	33

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ______

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ______

Failure Strain (%) ______

Compression Strength, q u (tsf) ______

Undrained Shear Strength, S u (tsf) ______

FAILURE

REMARKS: ______

Boring No. QRSB-79ST
Sample No.
Depth 9.4-11.4 ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (in.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name LP-533 Task 2
Test Date 11-16-01
Tested By DEB
Calculated By KAM
Checked By KF

Depth Feet	NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
				20" Feet Recovery Sample: Good Fair Poor Disturbed
9.4 save			PP=3.0 TV=.500	brown/gray sandy clay
Y				brown/gray sandy clay
10.4 Combo				brown/gray sandy clay
			PP=1.5 TV=.400	brown/gray sandy clay
11.4				

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt. + Tare			
Dry Wt. + Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content%			

F:\LABPLOGFORMS\LAB001.ERP

(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.875	(in.)		(cm)
Height	5.350	(in.)		(cm)
Area		(in²)		(cm²)
Volume		(ft³)		(cm³)
Wet Weight		(lbs)	1050	(gm)
Wet Density	115	(pcf)		(Kg/cm³)
Dry Density	85	(pcf)		(Kg/cm³)

WATER CONTENT	
Tare No.	E-5
Wet Wt. + Tare	1200
Dry Wt. + Tare	928
Wt. of Water	
Tare Wt.	150
Wt. of Dry Soil	
Water Content, %	35

☐ Load Cell ☐ Proving Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ________

Failure Strain (%) ________

Compression Strength, q u (tsf) ________

Undrained Shear Strength, S u (tsf) ________

FAILURE

REMARKS: ________

Boring No. QRSB-80 ST
Sample No.
Depth 9-11½ ft.
Sampling Method
Type of Sample Shelby Tube
Outside Diameter (in.) 3"

GEOTECHNOLOGY
ENGINEERING AND ENVIRONMENTAL SERVICES
SAINT LOUIS, MISSOURI

VISUAL CLASSIFICATION AND WATER CONTENT DETERMINATION

Job Number 05340.02.1153
Job Name WP-533 Task 2
Test Date 11-16-01
Tested By DEB
Calculated By KAB
Checked By KE

Depth Feet		NAT. W.C. Tare No.	NAT. W.C. W.C.	Type of Test	VISUAL CLASSIFICATION
					24" Feet Recovery Sample: ~~Good~~ Fair Poor Disturbed
9	Y			PP=2.25 TV=.850	brown & gray clay-CH
	hydro				AA
10	SAVE				gray sandy clay
				PP=2.50 TV=.300	AA
11					
11½					

NATURAL WATER CONTENT DETERMINATIONS

Tare No.			
Wet Wt. + Tare			
Dry Wt. + Tare			
Wt. of Water			
Tare Wt.			
Wt. of Dry Soil			
Water Content%			

F:\LABPROG\FORMS\LAB001.ERP

(CONTINUED ON REVERSE SIDE)

UNCONFINED COMPRESSION TEST
AND UNIT WEIGHT DETERMINATION

INITIAL CONDITION OF SPECIMEN				
Diameter	2.875	(in.)		(cm)
Height	5.791	(in.)		(cm)
Area		(in²)		(cm²)
Volume		(ft³)		(cm³)
Wet Weight		(lbs)	1104	(gm)
Wet Density	112.	(pcf)		(Kg/cm³)
Dry Density	79	(pcf)		(Kg/cm³)

WATER CONTENT	
Tare No.	C-11
Wet Wt. + Tare	1297
Dry Wt. + Tare	975
Wt. of Water	
Tare Wt.	193
Wt. of Dry Soil	
Water Content, %	41

☐ Load Cell ☐ Proving . Ring No. ___ Pounds Per Division ________

Dial Reading (0.001")	Load ☐ (lb) ☐ (div)	Dial Reading (0.001")	Load ☐ (lb) ☐ (div)
0	0	40	
20		60	
40		80	
60		600	
80		20	
100		40	
20		60	
40		80	
60		700	
80		20	
200		40	
20		60	
40		80	
60		800	
80		20	
300		40	
20		60	
40		80	
60		900	
80			
400			
20			
40			
60			
80			
500			
20			

FAILURE CONDITION

Deformation Rate (in./min.) ____________

Failure Strain (%) ____________

Compression Strength, q u (tsf) ____________

Undrained Shear Strength, S u (tsf) ______

FAILURE

REMARKS: ____________

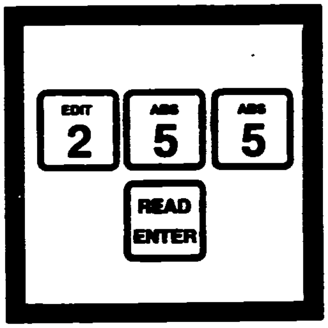
Method 8146

IRON, FERROUS (0 to 3.00 mg/L)

For water, wastewater and seawater

1,10 Phenanthroline Method* (Powder Pillows or AccuVac Ampuls)

USING POWDER PILLOWS



1. Enter the stored program number for ferrous iron, (Fe^{2+})– powder pillows.

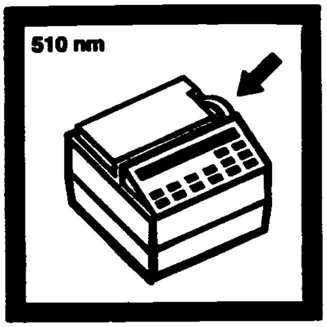
Press: **2 5 5 READ/ENTER**

The display will show:
DIAL nm TO 510

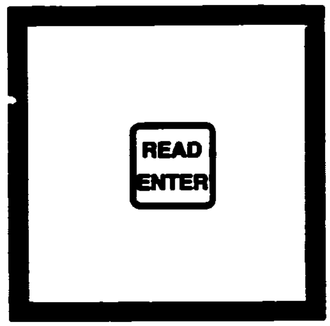
Note: DR/2000s with software versions 3.0 and greater will display "P" and the program number.

Note: Instruments with software versions 3.0 and greater will not display "DIAL nm TO" message if the wavelength is already set correctly. The display will show the message in Step 3. Proceed with Step 4.

Note: Analyze samples as soon as possible to prevent air oxidation of ferrous iron to ferric iron, which is not determined.

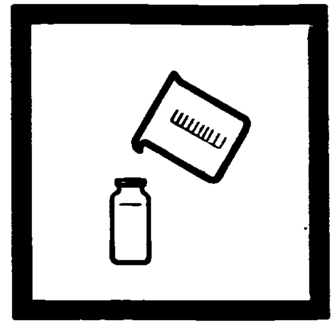


2. Rotate the wavelength dial until the small display shows:
510 nm



3. Press: **READ/ENTER**

The display will show:
mg/l Fe^{2+}



4. Fill a sample cell with 25 mL of sample.

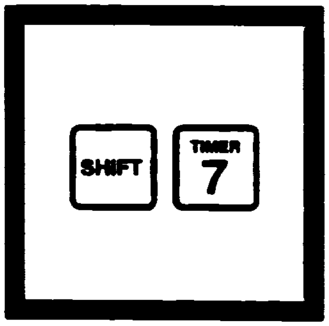
Note: For proof of accuracy, use a 1.0 mg/L ferrous iron standard solution (preparation given in the Accuracy Check) in place of the sample.

* Adapted from *Standard Methods for the Examination of Water and Wastewater*

5. Add the contents of one Ferrous Iron Reagent Powder Pillow to the sample cell (the prepared sample). Swirl to mix.

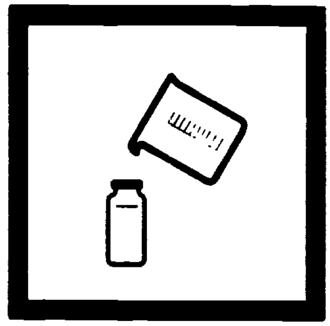
Note: An orange color will form if ferrous iron is present.

Note: Undissolved powder does not affect accuracy.



6. Press: **SHIFT TIMER**

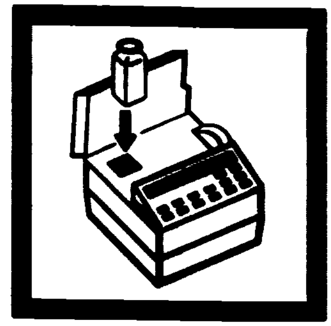
A 3–minute reaction period will begin.



7. When the timer beeps, the display will show:

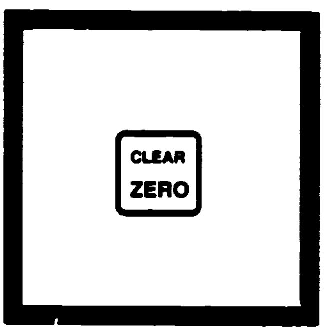
mg/l Fe^{2+}

Fill a second sample cell (the blank) with 25 mL of sample.



8. Place the blank into the cell holder. Close the light shield.

Note: The Pour–Thru Cell can be used with this procedure.



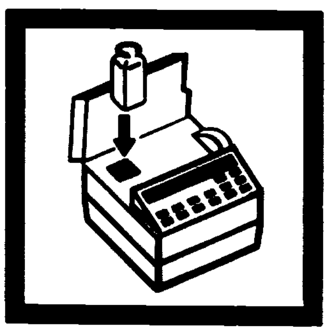
9. Press: **ZERO**

The display will show:

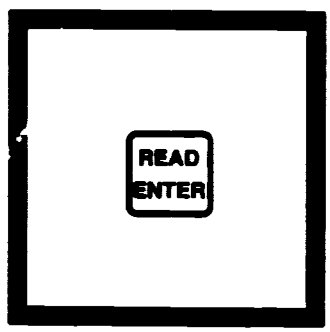
WAIT

then:

0.00 mg/l Fe^{2+}



10. Place the prepared sample into the cell holder. Close the light shield.



11. Press: **READ/ENTER**

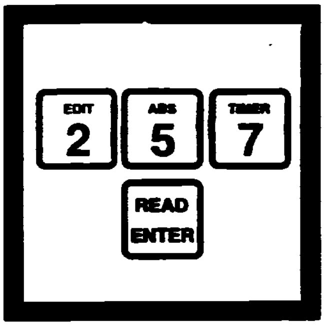
The display will show:

WAIT

then the result in mg/L Fe^{2+} will be displayed.

Note: In the constant–on mode, pressing READ/ENTER is not required. WAIT will not appear. When the display stabilizes, read the result.

USING ACCUVAC AMPULS



1. Enter the stored program number for ferrous iron (Fe^{2+})–AccuVac ampuls.

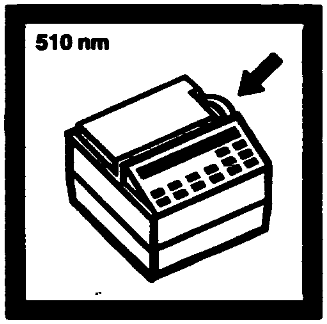
Press: **2 5 7 READ/ENTER**

The display will show:
DIAL nm TO 510

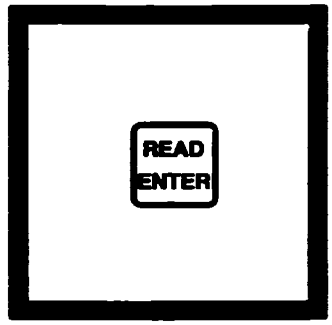
Note: DR/2000s with software versions 3.0 and greater will display "P" and the program number.

Note: Instruments with software versions 3.0 and greater will not display "DIAL nm TO" message if the wavelength is already set correctly. The display will show the message in Step 3. Proceed with Step 4.

Note: Analyze samples as soon as possible to prevent air oxidation of ferrous iron to ferric iron, which is not determined.

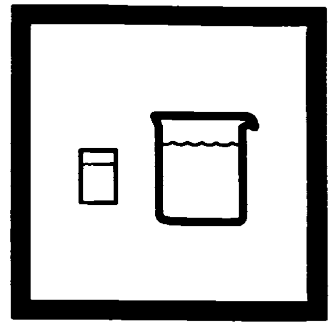


2. Rotate the wavelength dial until the small display shows:
510 nm



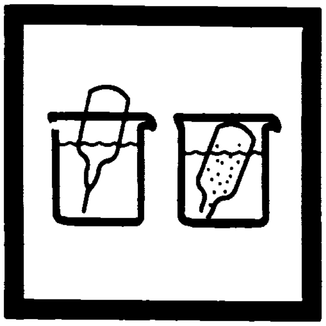
3. Press: **READ/ENTER**

The display will show:
mg/l Fe^{2+} AV



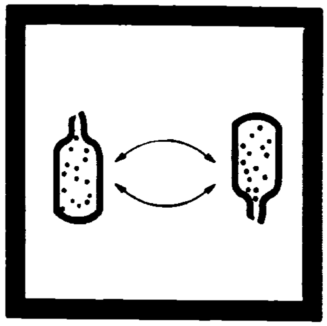
4. Fill a zeroing vial (the blank) with at least 10 mL of sample. Collect at least 40 mL of sample in a 50–mL beaker.

Note: For proof of accuracy, a 1.0 mg/L ferrous iron standard solution (preparation given in the Accuracy Check) can be used in place of the sample.



5. Fill a Ferrous Iron AccuVac Ampul with sample.

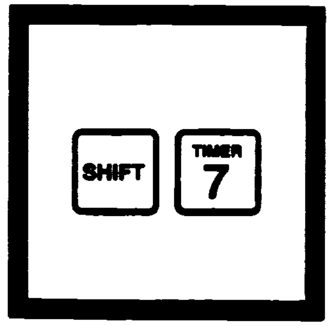
Note: Keep the tip immersed while the ampul fills completely.



6. Quickly invert the ampul several times to mix. Wipe off any liquid or fingerprints.

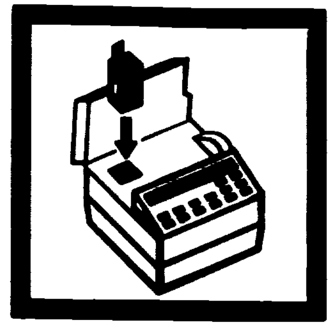
Note: An orange color will form if ferrous iron is present.

Note: Undissolved powder does not affect accuracy.



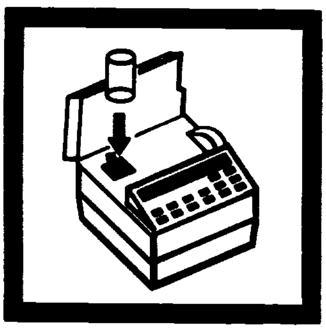
7. Press: **SHIFT TIMER**

A 3–minute reaction period will begin.



8. Place the AccuVac Vial Adapter into the cell holder.

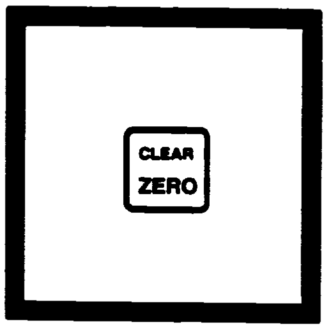
Note: Place the grip tab at the rear of the cell holder.



9. When the timer beeps, the display will show:

mg/l Fe^{2+} AV

Place the blank into the cell holder. Close the light shield.



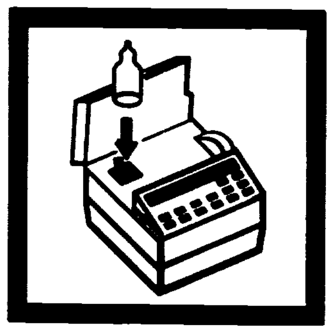
10. Press: **ZERO**

The display will show:

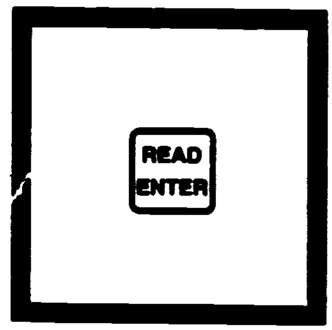
WAIT

then:

0.00 mg/l Fe^{2+} AV



11. Place the AccuVac ampul into the cell holder. Close the light shield.



12. Press: **READ/ENTER**

The display will show:

WAIT

then the result in mg/L Fe^{2+} will be displayed.

Note: In the constant–on mode, pressing READ/ENTER is not required. WAIT will not appear. When the display stabilizes, read the result.

ACCURACY CHECK

Standard Solution Method

Prepare a ferrous iron stock solution (100 mg/L Fe) by dissolving 0.7022 grams of ferrous ammonium sulfate, hexahydrate, in deionized water. Dilute to 1 liter. Prepare immediately before use. Dilute 1.00 mL of this solution to 100 mL with deionized water to make a 1.0 mg/L standard solution. Prepare this immediately before use.

PRECISION

In a single laboratory, using an iron standard solution of 1.000 mg/L Fe^{2+} and two representative lots of reagent with the DR/2000, a single operator obtained a standard deviation of ±0.006 mg/L Fe^{2+}.

In a single laboratory using a standard solution of 1.000 mg/L Fe^{2+} and two representative lots of AccuVac ampuls with the DR/2000, a single operator obtained a standard deviation of ±0.009 mg/L Fe^{2+}.

SUMMARY OF METHOD

The 1,10 phenanthroline indicator in Ferrous Iron Reagent reacts with ferrous iron in the sample to form an orange color in proportion to the iron concentration. Ferric iron does not react. The ferric iron (Fe^{3+}) concentration can be determined by subtracting the ferrous iron concentration from the results of a total iron test.

REQUIRED REAGENTS (Using Powder Pillows)

Description	Quantity Required Per Test	Units	Cat. No.
Ferrous Iron Reagent Powder Pillows	1 pillow	100/pkg	1037-69

REQUIRED REAGENTS (Using AccuVac Ampuls)

Ferrous Iron Reagent AccuVac Ampuls	1 ampul	25/pkg	25140-25

REQUIRED APPARATUS (Using Powder Pillows)

Clippers, for opening powder pillows	1	each	968-00

REQUIRED APPARATUS (Using AccuVac Ampuls)

Adapter, AccuVac Vial	1	each	43784-00
Beaker, 50 mL	1	each	500-41
Sample Cell, 10 mL, with cap	1	each	21228-00

OPTIONAL REAGENTS

Ferrous Ammonium Sulfate, hexahydrate, ACS	113 g	11256-14
Water, deionized	3.78 L	272-17

OPTIONAL APPARATUS

AccuVac Snapper Kit	each	24052-00
Clippers, shears, 7-1/4"	each	23694-00
Flask, volumetric, 100 mL, Class B	each	547-42
Flask, volumetric, 1000 mL, Class B	each	547-53
Pipet, volumetric, 1 mL	each	515-35
Pipet Filler, safety bulb	each	14651-00
Pour-Thru Cell Assembly Kit	each	45215-00

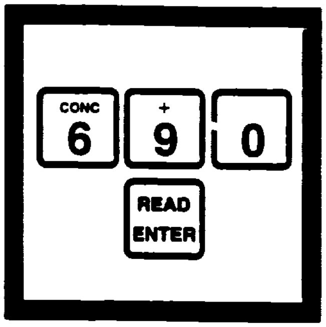
For additional ordering information, see final section.
In the U.S.A. call 800-227-4224 to place an order.

Method 8131

SULFIDE (0 to 0.600 mg/L S^{2-})

For water, wastewater and seawater

Methylene Blue Method*, USEPA accepted for reporting**



1. Enter the stored program for sulfide (S^{2-}).

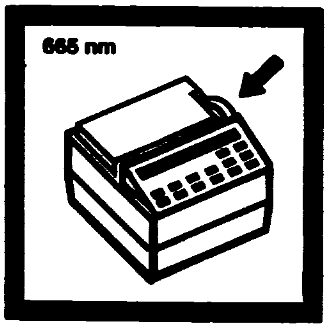
Press: **6 9 0 READ/ENTER**

The display will show:
DIAL nm to 665

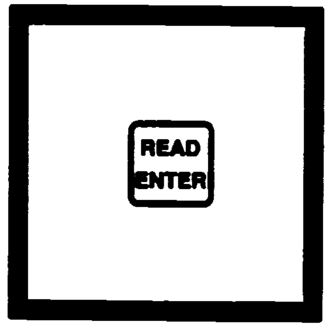
Note: DR/2000s with software versions 3.0 and greater will display "P" and the program number.

Note: Instruments with software versions 3.0 and greater will not display "DIAL nm TO" message if the wavelength is already set correctly. The display will show the message in Step 3. Proceed with Step 4.

Note: Samples must be analyzed immediately and cannot be preserved for later analysis. Avoid excessive agitation.

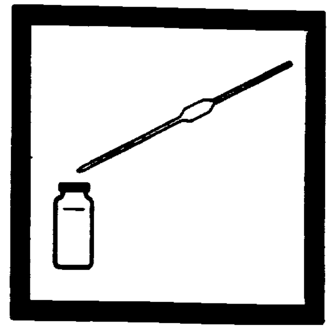


2. Rotate the wavelength dial until the small display shows:
665 nm



3. Press: **READ/ENTER**

The display will show:
mg/l S^{2-}

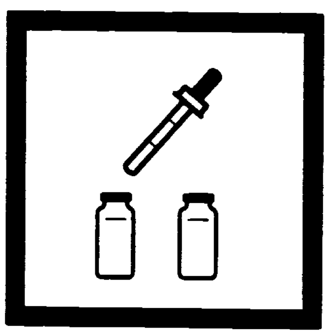


4. Fill a clean sample cell with 25 mL of sample.

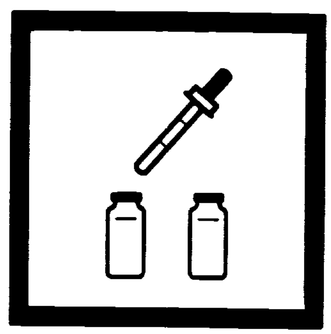
Note: For turbid samples, see Interferences following these steps for pretreatment instructions.

Note: Excessive agitation will cause loss of sulfide. Use a pipet to minimize sulfide loss.

5. Fill a second sample cell with 25 mL of deionized water (the blank).

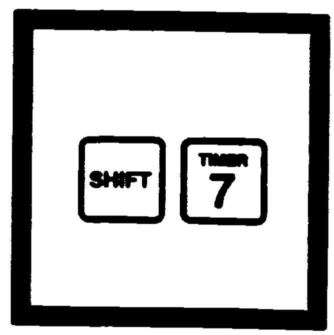


6. Add 1.0 mL of Sulfide 1 Reagent to each cell. Swirl to mix.



7. Add 1.0 mL of Sulfide 2 Reagent to each cell. Immediately swirl to mix.

Note: A pink color will develop, then the solution will turn blue if sulfide is present.

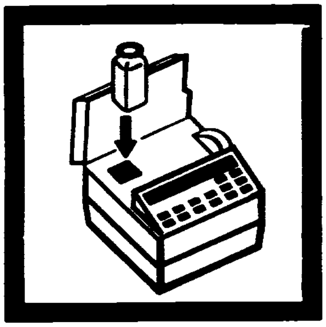


8. Press: **SHIFT TIMER**

A 5–minute reaction period will begin.

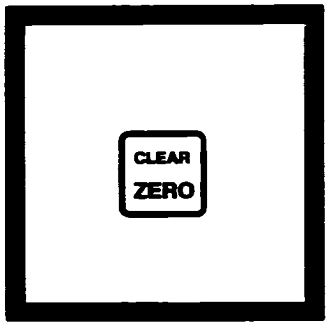
* Adapted from *Standard Methods for the Examination of Water and Wastewater*

**Procedure is equivalent to USEPA method 376.2 and Standard Method 4500–S^{2-} D for wastewater.



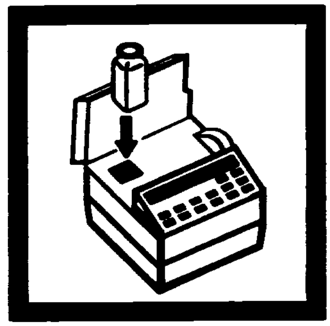
9. When the timer beeps, the display will show:
mg/l S^{2-}
Place the blank into the cell holder. Close the light shield.

Note: The Pour–Thru Cell can be used with this procedure.

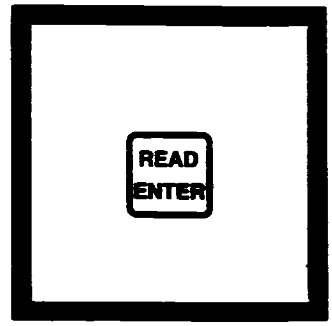


10. Press: **ZERO**

The display will show:
WAIT
then:
0.000 mg/l S^{2-}



11. Immediately place the prepared sample into the cell holder. Close the light shield.



12. Press: **READ/ENTER**

The display will show:
WAIT
then the result in mg/L sulfide (S^{2-}) will be displayed.

***Note:** In the constant on mode, pressing READ/ENTER is not required. WAIT will not appear. When the display stabilizes, read the result.*

SAMPLING
Collect samples in clean plastic or glass bottles. Fill completely and cap tightly. Avoid excessive agitation or prolonged exposure to air. Analyze samples immediately.

ACCURACY CHECK
Standard Solution Method
Sulfide standard solutions are very unstable and should be prepared from sodium sulfate and standardized as described in *Standard Methods for the Examination of Water and Wastewater*, 17th ed., page 4–196.

PRECISION
In a single laboratory, using standard solutions of 0.250 mg/L sulfide and two representative lots of reagent with the DR/2000, a single operator obtained a standard deviation of ± 0.003 mg/L sulfide.

INTERFERENCES
For turbid samples, prepare a sulfide–free blank as follows. Use it in place of the deionized water blank in the procedure.

a) Measure 25 mL of sample into a 50–mL erlenmeyer flask.

b) Add Bromine Water dropwise with constant swirling until a permanent yellow color just appears.

c) Add Phenol Solution dropwise until the yellow color just disappears. Use this solution in Step 5 in place of demineralized water.

Strong reducing substances such as sulfite, thiosulfate and hydrosulfite interfere by reducing the blue color or preventing its development. High concentrations of sulfide may inhibit full color development and require sample dilution. Some sulfide loss may occur when the sample is diluted.

DETERMINING SOLUBLE SULFIDES
Determine soluble sulfides by centrifuging the sample in completely filled, capped tubes and analyzing the supernatant. Insoluble sulfides are then estimated by subtracting the soluble sulfide concentration from the total sulfide result.

SUMMARY OF METHOD
Hydrogen sulfide and acid–soluble metal sulfides react with N,N–dimethyl–p–phenylenediamine oxalate to form methylene blue. The intensity of the blue color is proportional to the sulfide concentration.

High sulfide levels in oil field waters may be determined after proper dilution.

REQUIRED REAGENTS

			Cat. No.
Sulfide Reagent Set (100 tests)			22445–00
Includes: (2) 1816–42, (2) 1817–42			

Description	Quantity Required Per Test	Units	Cat. No.
Sulfide 1 Reagent	2 mL	100 mL MDB	1816–32
Sulfide 2 Reagent	2 mL	100 mL MDB	1817–32
Water, demineralized	25 mL	3.78 L	272–17
REQUIRED APPARATUS			
Cylinder, graduated, 25 mL	1	each	508–40
Pipet, volumetric, 25 mL	1	each	515–40
Pipet Filler, safety bulb	1	each	14651–00
OPTIONAL REAGENTS			
Bromine Water, 30 g/L		29 mL	2211–20
Phenol Solution, 30 g/L		29 mL	2112–20
Sodium Sulfide, hydrate		114 g	785–14
OPTIONAL APPARATUS			
Dropper, for 1 oz. bottle		each	2258–00
Flask, erlenmeyer, 50 mL		each	505–41
Pour–Thru Cell Kit		each	45215–00
Standard Methods for the Examination of Water and Wastewater		each	22708–00

For additional ordering information, see final section.
In the U.S.A. call 800–227–4224 to place an order.

Appendix C
Data Validation/QC Data

WSSRAP ID	QC Type	Location	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier	Comments
IS-QR77-D-DU	DU	QR77	11/12/2001	ALKALINITY	587		0.725	MG/L		*	RPD=0.00
IS-QR77-D-DU	DU	QR77	11/12/2001	ALUMINUM	4.77		9.54	UG/L		*	RPD=NC
IS-QR77-D-DU	DU	QR77	11/12/2001	CALCIUM	160000		24.7	UG/L		*	RPD=1.2
IS-QR77-D-DU	DU	QR77	11/12/2001	CHLORIDE	9.35		0.025	MG/L		*	RPD=3
IS-QR77-D-DU	DU	QR77	11/12/2001	IRON	16800		2.24	UG/L		*	RPD=1.2
IS-QR77-D-DU	DU	QR77	11/12/2001	MAGNESIUM	31600		5.14	UG/L		*	RPD=0.9
IS-QR77-D-DU	DU	QR77	11/12/2001	MANGANESE	3690		0.369	UG/L		*	RPD=0.8
IS-QR77-D-DU	DU	QR77	11/12/2001	NITRATE-N	0.00345		0.0069	MG/L		*	RPD=NC
IS-QR77-D-DU	DU	QR77	11/12/2001	POTASSIUM	5140		18.2	UG/L		*	RPD=1.2
IS-QR77-D-DU	DU	QR77	11/12/2001	SILICON	13400		9.9	UG/L		*	RPD=0.7
IS-QR77-D-DU	DU	QR77	11/12/2001	SODIUM	28300		15	UG/L		*	RPD=0.7
IS-QR77-D-DU	DU	QR77	11/12/2001	SULFATE	17.2		0.062	MG/L		*	RPD=3
IS-QR77-D-DU	DU	QR77	11/12/2001	URANIUM, TOTAL	77.4	2.75	0.0744	PCI/L		*	RPD=2
IS-QR77-D-FR	FR	QR77	11/12/2001	ALKALINITY	612		0.725	MG/L		*	RPD = 4.2
IS-QR77-D-FR	FR	QR77	11/12/2001	ALUMINUM	4.77		9.54	UG/L		*	RPD = NC
IS-QR77-D-FR	FR	QR77	11/12/2001	CALCIUM	160000		24.7	UG/L		*	RPD = 1.2
IS-QR77-D-FR	FR	QR77	11/12/2001	CHLORIDE	9.69		0.025	MG/L		*	RPD = 6.2
IS-QR77-D-FR	FR	QR77	11/12/2001	IRON	16400		2.24	UG/L		*	RPD = 3.6
IS-QR77-D-FR	FR	QR77	11/12/2001	MAGNESIUM	31800		5.14	UG/L		*	RPD = 0.3
IS-QR77-D-FR	FR	QR77	11/12/2001	MANGANESE	3710		0.369	UG/L		*	RPD = 0.3
IS-QR77-D-FR	FR	QR77	11/12/2001	NITRATE-N	0.00345		0.0069	MG/L		*	RPD = NC
IS-QR77-D-FR	FR	QR77	11/12/2001	POTASSIUM	5120		18.2	UG/L		*	RPD = 1.6
IS-QR77-D-FR	FR	QR77	11/12/2001	SILICON	13300		9.9	UG/L		*	RPD = 1.5
IS-QR77-D-FR	FR	QR77	11/12/2001	SODIUM	28000		15	UG/L		*	RPD = 1.8
IS-QR77-D-FR	FR	QR77	11/12/2001	SULFATE	24.1		0.062	MG/L		*	RPD = 36.9
IS-QR77-D-FR	FR	QR77	11/12/2001	URANIUM, TOTAL	82.4	2.93	0.0744	PCI/L		*	RPD = 8.6
IS-QR77-D-MD	MD	QR77	11/12/2001	ALUMINUM	5170		9.54	UG/L		*	%REC=103.2 RPD=0.2
IS-QR77-D-MD	MD	QR77	11/12/2001	CALCIUM	163000		24.7	UG/L		*	%REC=20.0 RPD=0.6
IS-QR77-D-MD	MD	QR77	11/12/2001	IRON	21600		2.24	UG/L		*	%REC=92.0 RPD=0.5
IS-QR77-D-MD	MD	QR77	11/12/2001	MAGNESIUM	36500		5.14	UG/L		*	%REC=92.0 RPD=0.3
IS-QR77-D-MD	MD	QR77	11/12/2001	MANGANESE	4190		0.369	UG/L		*	%REC=94.0 RPD=0.2
IS-QR77-D-MD	MD	QR77	11/12/2001	POTASSIUM	10100		18.2	UG/L		*	%REC=98.0 RPD=0.0
IS-QR77-D-MD	MD	QR77	11/12/2001	SILICON	18300		9.9	UG/L		*	%REC=96.0 RPD=0.5
IS-QR77-D-MD	MD	QR77	11/12/2001	SODIUM	33100		15	UG/L		*	%REC=92.0 RPD=0.6
IS-QR77-D-MS	MS	QR77	11/12/2001	ALKALINITY	632		0.725	MG/L		*	%REC=NC
IS-QR77-D-MS	MS	QR77	11/12/2001	ALUMINUM	5150		9.54	UG/L		*	%REC=103.0
IS-QR77-D-MS	MS	QR77	11/12/2001	CALCIUM	164000		24.7	UG/L		*	%REC=40.0
IS-QR77-D-MS	MS	QR77	11/12/2001	CHLORIDE	19.5		0.025	MG/L		*	%REC=104
IS-QR77-D-MS	MS	QR77	11/12/2001	IRON	21700		2.24	UG/L		*	%REC=94.0
IS-QR77-D-MS	MS	QR77	11/12/2001	MAGNESIUM	36600		5.14	UG/L		*	%REC=94.0
IS-QR77-D-MS	MS	QR77	11/12/2001	MANGANESE	4200		0.369	UG/L		*	%REC=96.0
IS-QR77-D-MS	MS	QR77	11/12/2001	NITRATE-N	0.77		0.0069	MG/L		*	%REC = 77

WSSRAP ID	QC Type	Location	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier	Comments
IS-QR77-D-MS	MS	QR77	11/12/2001	POTASSIUM	10100		18.2	UG/L		*	%REC=98.0
IS-QR77-D-MS	MS	QR77	11/12/2001	SILICON	18400		9.9	UG/L		*	%REC=98 0
IS-QR77-D-MS	MS	QR77	11/12/2001	SODIUM	33300		15	UG/L		*	%REC=96 0
IS-QR77-D-MS	MS	QR77	11/12/2001	SULFATE	39 3		0 062	MG/L		*	%REC=113
IS-QR77-D-MS	MS	QR77	11/12/2001	URANIUM, TOTAL	106	3 75	0.0744	PCI/L		*	%REC=90
IS-QR80-S-EB	EB	QR80	11/20/2001	ALKALINITY	7 65		0.725	MG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	ALUMINUM	4 77		9 54	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	CALCIUM	116		24.7	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	CHLORIDE	0.257		0 025	MG/L	H0/10	*	
IS-QR80-S-EB	EB	QR80	11/20/2001	IRON	19.2		2.24	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	MAGNESIUM	29.9		5.14	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	MANGANESE	1.33		0.369	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	NITRATE-N	0.0035		0.007	MG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	POTASSIUM	20.4		18.2	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	SILICON	40.2		9.9	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	SODIUM	16.7		15	UG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	SULFATE	6.21		0.062	MG/L		*	
IS-QR80-S-EB	EB	QR80	11/20/2001	URANIUM, TOTAL	0 129	0.006	0.074	PCI/L		*	

WSSRAP ID	QC Type	Location	Date Sampled	Parameter	Concentration	Error	Detection Limit	Units	Ver Qualifier	Val Qualifier	Comments
SO-100017-S-DU	DU	100017	11/14/2001	IRON	21300		1.8	UG/G		*	RPD = 4.3
SO-100017-S-DU	DU	100017	11/14/2001	MANGANESE	358		0.24	UG/G		*	RPD = 40
SO-100017-S-DU	DU	100017	11/14/2001	TOTAL ORGANIC CARBON	10300		33.7	UG/G		*	RPD = 18
SO-100017-S-DU	DU	100017	11/14/2001	URANIUM-234	0.86	0.32	0.09	PCI/G		*	RPD = 22
SO-100017-S-DU	DU	100017	11/14/2001	URANIUM-235	0.05	0.08	0.15	PCI/G		*	RPD = NC
SO-100017-S-DU	DU	100017	11/14/2001	URANIUM-238	1.17	0.39	0.09	PCI/G		*	RPD = 16
SO-100017-S-FR	FR	100017	11/14/2001	IRON	18300		1.9	UG/G		*	RPD = 10.9
SO-100017-S-FR	FR	100017	11/14/2001	MANGANESE	270		0.24	UG/G		*	RPD = 66.2
SO-100017-S-FR	FR	100017	11/14/2001	PERCENT MOISTURE	26.5		0.1	PRCNT		*	RPD = 2.7
SO-100017-S-FR	FR	100017	11/14/2001	TOTAL ORGANIC CARBON	9490		34	UG/G		*	RPD = 9.7
SO-100017-S-FR	FR	100017	11/14/2001	URANIUM-234	0.92	0.35	0.11	PCI/G		*	RPD = 16.0
SO-100017-S-FR	FR	100017	11/14/2001	URANIUM-235	0.08	0.096	0.13	PCI/G		*	RPD = 90.9
SO-100017-S-FR	FR	100017	11/14/2001	URANIUM-238	0.85	0.34	0.1	PCI/G		*	RPD = 15.2
SO-100017-S-MS	MS	100017	11/14/2001	IRON	19600		1.8	UG/G		*	%REC = 0
SO-100017-S-MS	MS	100017	11/14/2001	MANGANESE	754		0.24	UG/G		*	%REC = 322
SO-100017-S-MS	MS	100017	11/14/2001	TOTAL ORGANIC CARBON	20600		33.7	UG/G		*	%REC = 890
SO-100017-S-MS	MS	100017	11/14/2001	URANIUM-234	5.7	1.5	0.2	PCI/G		*	%REC = 185
SO-100017-S-MS	MS	100017	11/14/2001	URANIUM-238	6.7	1.7	0.2	PCI/G		*	%REC = 230
SO-100018-S-DU	DU	100018	11/13/2001	IRON	19700		1.8	UG/G		*	RPD = 25
SO-100018-S-DU	DU	100018	11/13/2001	MANGANESE	814		0.23	UG/G		*	RPD = 48
SO-100018-S-DU	DU	100018	11/13/2001	TOTAL ORGANIC CARBON	10000		32.6	UG/G		*	RPD = 7.6
SO-100018-S-DU	DU	100018	11/13/2001	URANIUM-234	0.73	0.26	0.09	PCI/G		*	RPD = 4
SO-100018-S-DU	DU	100018	11/13/2001	URANIUM-235	0.07	0.08	0.09	PCI/G		*	RPD = NC
SO-100018-S-DU	DU	100018	11/13/2001	URANIUM-238	0.83	0.29	0.07	PCI/G		*	RPD = 3
SO-100018-S-FR	FR	100018	11/13/2001	IRON	15100		1.8	UG/G		*	RPD = 2.0
SO-100018-S-FR	FR	100018	11/13/2001	MANGANESE	262		0.23	UG/G		*	RPD = 62.5
SO-100018-S-FR	FR	100018	11/13/2001	PERCENT MOISTURE	22.1		0.1	PRCNT		*	RPD = 5.7
SO-100018-S-FR	FR	100018	11/13/2001	TOTAL ORGANIC CARBON	9630		32.1	UG/G		*	RPD = 3.8
SO-100018-S-FR	FR	100018	11/13/2001	URANIUM-234	0.65	0.26	0.13	PCI/G		*	RPD = 15.6
SO-100018-S-FR	FR	100018	11/13/2001	URANIUM-235	0.06	0.075	0.1	PCI/G		*	RPD = NC
SO-100018-S-FR	FR	100018	11/13/2001	URANIUM-238	0.95	0.34	0.19	PCI/G		*	RPD = 7.7
SO-100018-S-MS	MS	100018	11/13/2001	IRON	15700		1.8	UG/G		*	%REC = 242
SO-100018-S-MS	MS	100018	11/13/2001	MANGANESE	421		0.23	UG/G		*	%REC = 0
SO-100018-S-MS	MS	100018	11/13/2001	TOTAL ORGANIC CARBON	15400		32.6	UG/G		*	%REC = 938
SO-100018-S-MS	MS	100018	11/13/2001	URANIUM-234	2.44	0.67	0.14	PCI/G		*	
SO-100018-S-MS	MS	100018	11/13/2001	URANIUM-238	2.84	0.76	0.08	PCI/G		*	
SO-100019-DU	DU	100019	11/16/2001	IRON	4070		1.36	UG/G		*	RPD = 1.5
SO-100019-DU	DU	100019	11/16/2001	MANGANESE	313		0.18	UG/G		*	RPD = 0.64
SO-100019-MS	MS	100019	11/16/2001	IRON	4080		6.8	UG/G		*	%REC = 0
SO-100019-MS	MS	100019	11/16/2001	MANGANESE	393		0.9	UG/G		*	%REC = 76

Appendix D
PHREEQC Model Output

Input file: quarry1
Output file: quarry1.out
Database file: wateq4f.dat

Reading data base.

```
SOLUTION_MASTER_SPECIES
SOLUTION_SPECIES
PHASES
EXCHANGE_MASTER_SPECIES
EXCHANGE_SPECIES
SURFACE_MASTER_SPECIES
SURFACE_SPECIES
RATES
END
```

Reading input data for simulation 1.

```
TITLE quarry - reducing sample from QR73-D
SOLUTION 1  QR73-D
     units  ppm
     pH     6.93
     pe                               -0.14
     temp   15.9
     Ca         173.0
     Mg          39.2
     Na          23.4
     K          3.6
     Fe          22.7
     Mn          3.1
     Si         23.0
     Cl         9.5
          Alkalinity 274.0 as Ca.5(CO3).5
     S(6)        7.6
                                             S(-2)
     U          2.2   ppb
END
```

TITLE

---

quarry - reducing sample from QR73-D

Beginning of initial solution calculations.

Initial soluti QR73-D

----------------------------Solution composition----------------------------

Elements	Molality	Moles
Alkalinity	5.478e-03	5.478e-03
Ca	4.319e-03	4.319e-03
Cl	2.681e-04	2.681e-04
Fe	4.067e-04	4.067e-04
K	9.212e-05	9.212e-05
Mg	1.613e-03	1.613e-03
Mn	5.646e-05	5.646e-05
Na	1.018e-03	1.018e-03
S(-2)	2.184e-07	2.184e-07
S(6)	7.916e-05	7.916e-05
Si	3.830e-04	3.830e-04
U	9.248e-09	9.248e-09

----------------------------Description of solution----------------------------

pH = 6.930
pe = -0.140
Activity of water = 1.000
Ionic strength = 1.562e-02
Mass of water (kg) = 1.000e+00
Total carbon (mol/kg) = 6.836e-03
Total CO2 (mol/kg) = 6.836e-03
Temperature (deg C) = 15.900
Electrical balance (eq) = 7.997e-03
Percent error, 100*(Cat-|An|)/(Cat+|An|) = 42.03
Iterations = 12
Total H = 1.110194e+02
Total O = 5.552720e+01

----------------------------Redox couples----------------------------

Redox couple	pe	Eh (volts)
S(-2)/S(6)	-3.0852	-0.1769

----------------------------Distribution of species----------------------------

	Species	Molality	Activity	Log Molality	Log Activity	Gamma
	H+	1.306e-07	1.175e-07	-6.884	-6.930	-0.046
	OH-	4.677e-08	4.136e-08	-7.330	-7.383	-0.053
	H2O	5.551e+01	9.997e-01	-0.000	-0.000	0.000
C(4)	6.836e-03					
	HCO3-	5.130e-03	4.558e-03	-2.290	-2.341	-0.051
	CO2	1.377e-03	1.382e-03	-2.861	-2.860	0.002
	CaHCO3+	1.436e-04	1.270e-04	-3.843	-3.896	-0.053
	FeHCO3+	9.558e-05	8.452e-05	-4.020	-4.073	-0.053

	MgHCO3+	5.688e-05	5.030e-05	-4.245	-4.298	-0.053
	MnHCO3+	1.169e-05	1.034e-05	-4.932	-4.985	-0.053
	FeCO3	6.561e-06	6.584e-06	-5.183	-5.181	0.002
	CaCO3	5.500e-06	5.519e-06	-5.260	-5.258	0.002
	MnCO3	2.982e-06	2.993e-06	-5.526	-5.524	0.002
	CO3-2	2.376e-06	1.480e-06	-5.624	-5.830	-0.206
	NaHCO3	2.298e-06	2.306e-06	-5.639	-5.637	0.002
	MgCO3	1.191e-06	1.196e-06	-5.924	-5.922	0.002
	NaCO3-	1.747e-08	1.545e-08	-7.758	-7.811	-0.053
	UO2(CO3)2-2	5.821e-09	3.560e-09	-8.235	-8.449	-0.214
	UO2(CO3)3-4	3.302e-09	4.617e-10	-8.481	-9.336	-0.854
	UO2CO3	1.213e-10	1.217e-10	-9.916	-9.915	0.002
	(UO2)3(CO3)6-6	7.633e-21	9.125e-23	-20.117	-22.040	-1.922
	UO2(CO3)3-5	1.652e-21	7.639e-23	-20.782	-22.117	-1.335
	U(CO3)4-4	1.390e-21	1.944e-22	-20.857	-21.711	-0.854
	U(CO3)5-6	1.047e-25	1.252e-27	-24.980	-26.902	-1.922
Ca	4.319e-03					
	Ca+2	4.154e-03	2.586e-03	-2.382	-2.587	-0.206
	CaHCO3+	1.436e-04	1.270e-04	-3.843	-3.896	-0.053
	CaSO4	1.618e-05	1.624e-05	-4.791	-4.789	0.002
	CaCO3	5.500e-06	5.519e-06	-5.260	-5.258	0.002
	CaOH+	4.130e-09	3.652e-09	-8.384	-8.437	-0.053
	CaHSO4+	1.140e-11	1.008e-11	-10.943	-10.996	-0.053
Cl	2.681e-04					
	Cl-	2.680e-04	2.363e-04	-3.572	-3.626	-0.055
	FeCl+	6.841e-08	6.050e-08	-7.165	-7.218	-0.053
	MnCl+	2.771e-08	2.451e-08	-7.557	-7.611	-0.053
	MnCl2	2.519e-12	2.528e-12	-11.599	-11.597	0.002
	MnCl3-	1.861e-16	1.646e-16	-15.730	-15.784	-0.053
	UO2Cl+	7.343e-18	6.493e-18	-17.134	-17.188	-0.053
	FeCl+2	6.649e-20	4.066e-20	-19.177	-19.391	-0.214
	UO2Cl2	7.503e-23	7.530e-23	-22.125	-22.123	0.002
	FeCl2+	6.536e-23	5.780e-23	-22.185	-22.238	-0.053
	FeCl3	1.361e-27	1.366e-27	-26.866	-26.865	0.002
	UCl+3	2.435e-33	8.050e-34	-32.614	-33.094	-0.481
Fe(2)	4.067e-04					
	Fe+2	3.033e-04	1.854e-04	-3.518	-3.732	-0.214
	FeHCO3+	9.558e-05	8.452e-05	-4.020	-4.073	-0.053
	FeCO3	6.561e-06	6.584e-06	-5.183	-5.181	0.002
	FeSO4	9.508e-07	9.542e-07	-6.022	-6.020	0.002
	FeOH+	2.798e-07	2.475e-07	-6.553	-6.606	-0.053
	FeCl+	6.841e-08	6.050e-08	-7.165	-7.218	-0.053
	Fe(HS)2	1.198e-09	1.203e-09	-8.921	-8.920	0.002
	Fe(OH)2	7.893e-12	7.922e-12	-11.103	-11.101	0.002
	FeHSO4+	8.175e-13	7.229e-13	-12.088	-12.141	-0.053
	Fe(HS)3-	1.263e-14	1.117e-14	-13.899	-13.952	-0.053
	Fe(OH)3-	2.583e-15	2.284e-15	-14.588	-14.641	-0.053
Fe(3)	8.910e-10					
	Fe(OH)2+	5.413e-10	4.786e-10	-9.267	-9.320	-0.053
	Fe(OH)3	3.473e-10	3.485e-10	-9.459	-9.458	0.002
	Fe(OH)4-	2.097e-12	1.855e-12	-11.678	-11.732	-0.053
	FeOH+2	3.966e-13	2.425e-13	-12.402	-12.615	-0.214

	Fe+3	2.320e-17	7.671e-18	-16.635	-17.115	-0.481
	FeSO4+	2.655e-18	2.347e-18	-17.576	-17.629	-0.053
	FeCl+2	6.649e-20	4.066e-20	-19.177	-19.391	-0.214
	Fe(SO4)2-	1.923e-21	1.701e-21	-20.716	-20.769	-0.053
	FeCl2+	6.536e-23	5.780e-23	-22.185	-22.238	-0.053
	Fe2(OH)2+4	1.669e-23	2.333e-24	-22.778	-23.632	-0.854
	FeHSO4+2	1.228e-24	7.511e-25	-23.911	-24.124	-0.214
	FeCl3	1.361e-27	1.366e-27	-26.866	-26.865	0.002
	Fe3(OH)4+5	1.200e-29	5.547e-31	-28.921	-30.256	-1.335
H(0)	4.074e-17					
	H2	2.037e-17	2.045e-17	-16.691	-16.689	0.002
K	9.212e-05					
	K+	9.210e-05	8.121e-05	-4.036	-4.090	-0.055
	KSO4-	1.882e-08	1.664e-08	-7.725	-7.779	-0.053
Mg	1.613e-03					
	Mg+2	1.549e-03	9.735e-04	-2.810	-3.012	-0.202
	MgHCO3+	5.688e-05	5.030e-05	-4.245	-4.298	-0.053
	MgSO4	6.134e-06	6.156e-06	-5.212	-5.211	0.002
	MgCO3	1.191e-06	1.196e-06	-5.924	-5.922	0.002
	MgOH+	1.457e-08	1.289e-08	-7.836	-7.890	-0.053
Mn(2)	5.646e-05					
	Mn+2	4.163e-05	2.545e-05	-4.381	-4.594	-0.214
	MnHCO3+	1.169e-05	1.034e-05	-4.932	-4.985	-0.053
	MnCO3	2.982e-06	2.993e-06	-5.526	-5.524	0.002
	MnSO4	1.295e-07	1.300e-07	-6.888	-6.886	0.002
	MnCl+	2.771e-08	2.451e-08	-7.557	-7.611	-0.053
	MnOH+	2.929e-09	2.590e-09	-8.533	-8.587	-0.053
	MnCl2	2.519e-12	2.528e-12	-11.599	-11.597	0.002
	MnCl3-	1.861e-16	1.646e-16	-15.730	-15.784	-0.053
	Mn(OH)3-	2.811e-19	2.486e-19	-18.551	-18.605	-0.053
Mn(3)	4.375e-31					
	Mn+3	4.375e-31	1.447e-31	-30.359	-30.840	-0.481
Mn(6)	0.000e+00					
	MnO4-2	0.000e+00	0.000e+00	-71.403	-71.617	-0.214
Mn(7)	0.000e+00					
	MnO4-	0.000e+00	0.000e+00	-81.701	-81.754	-0.053
Na	1.018e-03					
	Na+	1.016e-03	8.998e-04	-2.993	-3.046	-0.053
	NaHCO3	2.298e-06	2.306e-06	-5.639	-5.637	0.002
	NaSO4-	1.651e-07	1.460e-07	-6.782	-6.836	-0.053
	NaCO3-	1.747e-08	1.545e-08	-7.758	-7.811	-0.053
O(0)	0.000e+00					
	O2	0.000e+00	0.000e+00	-62.032	-62.031	0.002
S(-2)	2.184e-07					
	H2S	1.175e-07	1.180e-07	-6.930	-6.928	0.002
	HS-	9.646e-08	8.530e-08	-7.016	-7.069	-0.053
	Fe(HS)2	1.198e-09	1.203e-09	-8.921	-8.920	0.002
	S5-2	1.658e-10	1.125e-10	-9.780	-9.949	-0.168
	S6-2	1.379e-10	9.549e-11	-9.860	-10.020	-0.160
	S4-2	9.688e-11	6.429e-11	-10.014	-10.192	-0.178
	S-2	7.539e-14	4.610e-14	-13.123	-13.336	-0.214
	S3-2	3.373e-14	2.183e-14	-13.472	-13.661	-0.189

	Fe(HS)3-	1.263e-14	1.117e-14	-13.899	-13.952	-0.053
	S2-2	1.854e-15	1.175e-15	-14.732	-14.930	-0.198
S(6)	7.916e-05					
	SO4-2	5.558e-05	3.435e-05	-4.255	-4.464	-0.209
	CaSO4	1.618e-05	1.624e-05	-4.791	-4.789	0.002
	MgSO4	6.134e-06	6.156e-06	-5.212	-5.211	0.002
	FeSO4	9.508e-07	9.542e-07	-6.022	-6.020	0.002
	NaSO4-	1.651e-07	1.460e-07	-6.782	-6.836	-0.053
	MnSO4	1.295e-07	1.300e-07	-6.888	-6.886	0.002
	KSO4-	1.882e-08	1.664e-08	-7.725	-7.779	-0.053
	HSO4-	3.666e-10	3.242e-10	-9.436	-9.489	-0.053
	CaHSO4+	1.140e-11	1.008e-11	-10.943	-10.996	-0.053
	FeHSO4+	8.175e-13	7.229e-13	-12.088	-12.141	-0.053
	UO2SO4	7.740e-16	7.768e-16	-15.111	-15.110	0.002
	FeSO4+	2.655e-18	2.347e-18	-17.576	-17.629	-0.053
	UO2(SO4)2-2	3.504e-19	2.142e-19	-18.455	-18.669	-0.214
	Fe(SO4)2-	1.923e-21	1.701e-21	-20.716	-20.769	-0.053
	FeHSO4+2	1.228e-24	7.511e-25	-23.911	-24.124	-0.214
	USO4+2	9.846e-30	6.021e-30	-29.007	-29.220	-0.214
	U(SO4)2	1.253e-30	1.257e-30	-29.902	-29.901	0.002
Si	3.830e-04					
	H4SiO4	3.826e-04	3.840e-04	-3.417	-3.416	0.002
	H3SiO4-	3.894e-07	3.444e-07	-6.410	-6.463	-0.053
	H2SiO4-2	1.744e-13	1.066e-13	-12.758	-12.972	-0.214
U(3)	0.000e+00					
	U+3	0.000e+00	0.000e+00	-40.031	-40.512	-0.481
U(4)	2.272e-13					
	U(OH)4	2.271e-13	2.279e-13	-12.644	-12.642	0.002
	U(OH)3+	1.239e-16	1.096e-16	-15.907	-15.960	-0.053
	U(OH)2+2	1.264e-20	7.730e-21	-19.898	-20.112	-0.214
	U(CO3)4-4	1.390e-21	1.944e-22	-20.857	-21.711	-0.854
	UOH+3	2.086e-25	6.898e-26	-24.681	-25.161	-0.481
	U(CO3)5-6	1.047e-25	1.252e-27	-24.980	-26.902	-1.922
	USO4+2	9.846e-30	6.021e-30	-29.007	-29.220	-0.214
	U(SO4)2	1.253e-30	1.257e-30	-29.902	-29.901	0.002
	U+4	3.647e-31	5.099e-32	-30.438	-31.292	-0.854
	UCl+3	2.435e-33	8.050e-34	-32.614	-33.094	-0.481
	U6(OH)15+9	0.000e+00	0.000e+00	-96.681	-101.006	-4.325
U(5)	1.181e-12					
	UO2+	1.181e-12	1.045e-12	-11.928	-11.981	-0.053
	UO2(CO3)3-5	1.652e-21	7.639e-23	-20.782	-22.117	-1.335
U(6)	9.247e-09					
	UO2(CO3)2-2	5.821e-09	3.560e-09	-8.235	-8.449	-0.214
	UO2(CO3)3-4	3.302e-09	4.617e-10	-8.481	-9.336	-0.854
	UO2CO3	1.213e-10	1.217e-10	-9.916	-9.915	0.002
	UO2(OH)3-	9.034e-13	7.989e-13	-12.044	-12.098	-0.053
	UO2OH+	6.949e-13	6.145e-13	-12.158	-12.211	-0.053
	UO2+2	3.360e-14	2.055e-14	-13.474	-13.687	-0.214
	UO2SO4	7.740e-16	7.768e-16	-15.111	-15.110	0.002
	UO2Cl+	7.343e-18	6.493e-18	-17.134	-17.188	-0.053
	UO2(SO4)2-2	3.504e-19	2.142e-19	-18.455	-18.669	-0.214
	UO2(OH)4-2	1.762e-19	1.077e-19	-18.754	-18.968	-0.214

(UO2)2(OH)2+2	6.965e-20	4.259e-20	-19.157	-19.371	-0.214
(UO2)3(CO3)6-6	7.633e-21	9.125e-23	-20.117	-22.040	-1.922
UO2Cl2	7.503e-23	7.530e-23	-22.125	-22.123	0.002
(UO2)3(OH)5+	3.255e-23	2.879e-23	-22.487	-22.541	-0.053
(UO2)2OH+3	2.168e-23	7.169e-24	-22.664	-23.145	-0.481
(UO2)3(OH)7-	3.170e-24	2.803e-24	-23.499	-23.552	-0.053
(UO2)3(OH)4+2	9.366e-26	5.727e-26	-25.028	-25.242	-0.214
(UO2)4(OH)7+	8.200e-29	7.251e-29	-28.086	-28.140	-0.053

------------------------------Saturation indices------------------------------

Phase	SI	log IAP	log KT	
Anhydrite	-2.72	-7.05	-4.34	CaSO4
Aragonite	-0.13	-8.42	-8.28	CaCO3
Artinite	-8.26	2.01	10.26	MgCO3:Mg(OH)2:3H2O
B-UO2(OH)2	-5.69	0.17	5.86	UO2(OH)2
Birnessite	-20.76	22.85	43.60	MnO2
Bixbyite	-19.84	32.11	51.95	Mn2O3
Brucite	-6.62	10.85	17.47	Mg(OH)2
Calcite	0.02	-8.42	-8.43	CaCO3
Chalcedony	0.24	-3.42	-3.66	SiO2
Chrysotile	-7.65	25.71	33.36	Mg3Si2O5(OH)4
Clinoenstatite	-4.37	7.43	11.80	MgSiO3
CO2(g)	-1.51	-19.69	-18.18	CO2
Coffinite	0 41	-16.82	-17.24	USiO4
Cristobalite	0.30	-3.42	-3.71	SiO2
Diopside	-5 35	15.29	20.64	CaMgSi2O6
Dolomite	-0.39	-17.26	-16.87	CaMg(CO3)2
Dolomite(d)	-0.97	-17.26	-16.28	CaMg(CO3)2
Epsomite	-5.27	-7.48	-2.21	MgSO4:7H2O
Fe(OH)2.7Cl.3	3.55	13.75	10.20	Fe(OH)2.7Cl0.3
Fe(OH)3(a)	-1.22	16.92	18.13	Fe(OH)3
Fe3(OH)8	-2.74	43.96	46.71	Fe3(OH)8
FeS(ppt)	0.04	3.20	3.16	FeS
Forsterite	-11.15	18.28	29.43	Mg2SiO4
Goethite	4.34	16.92	12.58	FeOOH
Greenalite	2.74	23.55	20.81	Fe3Si2O5(OH)4
Greigite	6.52	16.25	9.73	Fe3S4
Gummite	-10.76	0.17	10.93	UO3
Gypsum	-2 47	-7.05	-4.58	CaSO4:2H2O
H2(g)	-13.58	-13.58	0.00	H2
H2O(g)	-1.75	-0.00	1.75	H2O
H2S(g)	-6.04	-6.93	-0.89	H2S
Halite	-8.23	-6.67	1.56	NaCl
Hausmannite	-21.98	41.38	63.35	Mn3O4
Hematite	10.65	33.84	23.19	Fe2O3
Huntite	-5.57	-34.94	-29.37	CaMg3(CO3)4
Hydromagnesite	-16.96	-24.52	-7.56	Mg5(CO3)4(OH)2:4H2O
Jarosite(ss)	-13.49	16.41	29.90	(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
Jarosite-K	-14.30	16.95	31.24	KFe3(SO4)2(OH)6
Jarosite-Na	-17.29	17.99	35.29	NaFe3(SO4)2(OH)6

JarositeH	-21.51	14.11	35.61	(H3O)Fe3(SO4)2(OH)6
Mackinawite	0.78	3.20	2.42	FeS
Magadiite	-5.72	-20.02	-14.30	NaSi7O13(OH)3:3H2O
Maghemite	0.96	33.84	32.87	Fe2O3
Magnesite	-0.95	-8.84	-7.89	MgCO3
Magnetite	12.58	43.96	31.39	Fe3O4
Manganite	-9.28	16.06	25.34	MnOOH
Melanterite	-5.87	-8.20	-2.33	FeSO4:7H2O
Mirabilite	-9.00	-10.56	-1.55	Na2SO4:10H2O
Mn2(SO4)3	-70.26	-22.86	47.40	Mn2(SO4)3
MnCl2:4H2O	-14.16	-11.85	2.31	MnCl2:4H2O
MnS(Green)	-8.67	2.34	11.00	MnS
MnSO4	-12.08	-9.06	3.03	MnSO4
Na4UO2(CO3)3	-27.07	-43.36	-16.29	Na4UO2(CO3)3
Nahcolite	-4.75	-15.81	-11.05	NaHCO3
Natron	-10.25	-11.92	-1.67	Na2CO3:10H2O
Nesquehonite	-3.35	-8.84	-5.49	MgCO3:3H2O
Nsutite	-19.72	22.85	42.56	MnO2
O2(g)	-59.11	27.16	86.27	O2
Portlandite	-12.24	11.27	23.52	Ca(OH)2
Pyrite	14.45	9.85	-4.60	FeS2
Pyrochroite	-5.93	9.27	15.20	Mn(OH)2
Pyrolusite	-20.04	22.85	42.88	MnO2
Quartz	0.70	-3.42	-4.12	SiO2
Rhodochrosite	0.67	-10.42	-11.10	MnCO3
Rhodochrosite(d)	-0.03	-10.42	-10.39	MnCO3
Rutherfordine	-5.10	-19.52	-14.42	UO2CO3
Schoepite	-5.51	0.17	5.68	UO2(OH)2:H2O
Sepiolite	-4.56	11.45	16.01	Mg2Si3O7.5OH:3H2O
Sepiolite(d)	-7.21	11.45	18.66	Mg2Si3O7.5OH:3H2O
Siderite	1.27	-9.56	-10.83	FeCO3
Siderite(d)(3)	0.89	-9.56	-10.45	FeCO3
Silicagel	-0.29	-3.42	-3.12	SiO2
SiO2(a)	-0.63	-3.42	-2.79	SiO2
Sulfur	1.59	6.65	5.06	S
Talc	-3.59	18.88	22.47	Mg3Si4O10(OH)2
Thenardite	-10.39	-10.56	-0.17	Na2SO4
Thermonatrite	-12.11	-11.92	0.19	Na2CO3:H2O
Tremolite	-9.35	49.46	58.81	Ca2Mg5Si8O22(OH)2
Trona	-16.93	-27.73	-10.80	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-18.70	-31.73	-13.03	U(OH)2SO4
U3O8(c)	-6.77	-13.06	-6.30	U3O8
U4O9(c)	0.34	-40.05	-40.39	U4O9
UO2(a)	-3.67	-13.41	-9.73	UO2
UO3(gamma)	-7.99	0.17	8.16	UO3
Uraninite(c)	0.80	-13.41	-14.21	UO2
Uranophane	-12.70	4.79	17.49	Ca(UO2)2(SiO3OH)2

End of simulation.

```
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Reading input data for simulation 2.
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-----------
End of run.
-----------
```

Input file: quarry2
Output file: quarry2.out
Database file: wateq4f.dat

Reading data base.

```
        SOLUTION_MASTER_SPECIES
        SOLUTION_SPECIES
        PHASES
        EXCHANGE_MASTER_SPECIES
        EXCHANGE_SPECIES
        SURFACE_MASTER_SPECIES
        SURFACE_SPECIES
        RATES
        END
```

Reading input data for simulation 1.

```
        TITLE quarry - oxidizing sample from QR75-S
        SOLUTION 1  QR75-S
            units  ppm
            pH     6.94
            pe                          2.31
            temp   17.3
            Ca         163.0
            Mg         31.8
            Na         30.8
            K          12.1
            Fe         0.002
            Mn         .135
            Si         12.7
            Cl         14.9
            Alkalinity  242.5 as Ca.5(CO3).5
            S(6)       35.7
                                            S(-2)
            U          3101    ppb
        END
```

TITLE

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quarry - oxidizing sample from QR75-S

Beginning of initial solution calculations.

Initial soluti QR75-S

----------------------------Solution composition----------------------------

Elements	Molality	Moles
Alkalinity	4.848e-03	4.848e-03
Ca	4.069e-03	4.069e-03
Cl	4.205e-04	4.205e-04
Fe	3.583e-08	3.583e-08
K	3.096e-04	3.096e-04
Mg	1.309e-03	1.309e-03
Mn	2.459e-06	2.459e-06
Na	1.340e-03	1.340e-03
S(6)	3 718e-04	3.718e-04
Si	2 115e-04	2.115e-04
U	1.303e-05	1.303e-05

----------------------------Description of solution----------------------------

pH = 6.940
pe = 2.310
Activity of water = 1.000
Ionic strength = 1.422e-02
Mass of water (kg) = 1.000e+00
Total carbon (mol/kg) = 5.993e-03
Total CO2 (mol/kg) = 5.993e-03
Temperature (deg C) = 17.300
Electrical balance (eq) = 6.424e-03
Percent error, 100*(Cat-|An|)/(Cat+|An|) = 36 46
Iterations = 11
Total H = 1 110181e+02
Total O = 5.552537e+01

----------------------------Distribution of species----------------------------

	Species	Molality	Activity	Log Molality	Log Activity	Log Gamma
	H+	1.272e-07	1.148e-07	-6.896	-6.940	-0.044
	OH-	5.349e-08	4.752e-08	-7.272	-7.323	-0.051
	H2O	5.551e+01	9.998e-01	-0.000	-0.000	0.000
C(4)	5.993e-03					
	HCO3-	4.601e-03	4.105e-03	-2.337	-2.387	-0.050
	CO2	1.183e-03	1.187e-03	-2.927	-2.926	0.001
	CaHCO3+	1.255e-04	1.115e-04	-3.901	-3.953	-0.051
	MgHCO3+	4.167e-05	3.701e-05	-4.380	-4.432	-0.051
	UO2(CO3)2-2	8.809e-06	5.485e-06	-5.055	-5.261	-0.206
	CaCO3	5.058e-06	5.074e-06	-5.296	-5.295	0.001
	UO2(CO3)3-4	4.032e-06	6.060e-07	-5.394	-6.218	-0.823
	NaHCO3	2.736e-06	2.745e-06	-5.563	-5.561	0.001
	CO3-2	2.229e-06	1.413e-06	-5.652	-5.850	-0.198
	MgCO3	9.459e-07	9.490e-07	-6.024	-6.023	0.001
	MnHCO3+	4 694e-07	4 170e-07	-6.328	-6.380	-0.051

	UO2CO3	1.907e-07	1.913e-07	-6.720	-6.718	0.001
	MnCO3	1.275e-07	1.279e-07	-6.895	-6.893	0.001
	NaCO3-	2.363e-08	2.099e-08	-7.627	-7.678	-0.051
	FeHCO3+	7.767e-09	6.899e-09	-8.110	-8.161	-0.051
	FeCO3	5.676e-10	5.695e-10	-9.246	-9.245	0.001
	(UO2)3(CO3)6-6	2.123e-11	2.987e-13	-10.673	-12.525	-1.852
	UO2(CO3)3-5	7.421e-21	3.841e-22	-20.130	-21.416	-1.286
	U(CO3)4-4	1.504e-23	2.261e-24	-22.823	-23.646	-0.823
	U(CO3)5-6	1.168e-27	1.643e-29	-26.933	-28.784	-1.852
Ca	4.069e-03					
	Ca+2	3.862e-03	2.446e-03	-2.413	-2.612	-0.198
	CaHCO3+	1.255e-04	1.115e-04	-3.901	-3.953	-0.051
	CaSO4	7.633e-05	7.658e-05	-4.117	-4.116	0.001
	CaCO3	5.058e-06	5.074e-06	-5.296	-5.295	0.001
	CaOH+	3.979e-09	3.535e-09	-8.400	-8.452	-0.051
	CaHSO4+	5.306e-11	4.714e-11	-10.275	-10.327	-0.051
Cl	4.205e-04					
	Cl-	4.205e-04	3.726e-04	-3.376	-3.429	-0.053
	MnCl+	1.947e-09	1.730e-09	-8.711	-8.762	-0.051
	FeCl+	9.731e-12	8.644e-12	-11.012	-11.063	-0.051
	MnCl2	2.804e-13	2.813e-13	-12.552	-12.551	0.001
	UO2Cl+	1.909e-14	1.696e-14	-13.719	-13.771	-0.051
	MnCl3-	3.250e-17	2.887e-17	-16.488	-16.540	-0.051
	UO2Cl2	3.134e-19	3.144e-19	-18.504	-18.502	0.001
	FeCl+2	2.989e-21	1.861e-21	-20.524	-20.730	-0.206
	FeCl2+	4.480e-24	3.979e-24	-23.349	-23.400	-0.051
	FeCl3	1.478e-28	1.483e-28	-27.830	-27.829	0.001
	UCl+3	4.974e-35	1.713e-35	-34.303	-34.766	-0.463
Fe(2)	3.580e-08					
	Fe+2	2.699e-08	1.681e-08	-7.569	-7.775	-0.206
	FeHCO3+	7.767e-09	6.899e-09	-8.110	-8.161	-0.051
	FeCO3	5.676e-10	5.695e-10	-9.246	-9.245	0.001
	FeSO4	4.355e-10	4.370e-10	-9.361	-9.360	0.001
	FeOH+	2.886e-11	2.564e-11	-10.540	-10.591	-0.051
	FeCl+	9.731e-12	8.644e-12	-11.012	-11.063	-0.051
	Fe(OH)2	9.523e-16	9.555e-16	-15.021	-15.020	0.001
	FeHSO4+	3.646e-16	3.239e-16	-15.438	-15.490	-0.051
	Fe(OH)3-	3.220e-19	2.860e-19	-18.492	-18.544	-0.051
Fe(3)	3.084e-11					
	Fe(OH)2+	1.804e-11	1.603e-11	-10.744	-10.795	-0.051
	Fe(OH)3	1.270e-11	1.274e-11	-10.896	-10.895	0.001
	Fe(OH)4-	8.290e-14	7.364e-14	-13.081	-13.133	-0.051
	FeOH+2	1.205e-14	7.502e-15	-13.919	-14.125	-0.206
	Fe+3	6.171e-19	2.125e-19	-18.210	-18.673	-0.463
	FeSO4+	3.720e-19	3.305e-19	-18.429	-18.481	-0.051
	FeCl+2	2.989e-21	1.861e-21	-20.524	-20.730	-0.206
	Fe(SO4)2-	1.333e-21	1.184e-21	-20.875	-20.927	-0.051
	FeCl2+	4.480e-24	3.979e-24	-23.349	-23.400	-0.051
	FeHSO4+2	1.652e-25	1.029e-25	-24.782	-24.988	-0.206
	Fe2(OH)2+4	1.397e-26	2.100e-27	-25.855	-26.678	-0.823
	FeCl3	1.478e-28	1.483e-28	-27.830	-27.829	0.001
	Fe3(OH)4+5	2.817e-34	1.458e-35	-33.550	-34.836	-1.286

H(0)	4.828e-22					
	H2	2.414e-22	2.422e-22	-21.617	-21.616	0.001
K	3.096e-04					
	K+	3.093e-04	2.740e-04	-3.510	-3.562	-0.053
	KSO4-	3.190e-07	2.834e-07	-6.496	-6.548	-0.051
Mg	1.309e-03					
	Mg+2	1.241e-03	7.924e-04	-2.906	-3.101	-0.195
	MgHCO3+	4.167e-05	3.701e-05	-4.380	-4.432	-0.051
	MgSO4	2.552e-05	2.560e-05	-4.593	-4.592	0.001
	MgCO3	9.459e-07	9.490e-07	-6.024	-6.023	0.001
	MgOH+	1.381e-08	1.227e-08	-7.860	-7.911	-0.051
Mn(2)	2.459e-06					
	Mn+2	1.830e-06	1.140e-06	-5.737	-5.943	-0.206
	MnHCO3+	4.694e-07	4.170e-07	-6.328	-6.380	-0.051
	MnCO3	1.275e-07	1.279e-07	-6.895	-6.893	0.001
	MnSO4	2.935e-08	2.945e-08	-7.532	-7.531	0.001
	MnCl+	1.947e-09	1.730e-09	-8.711	-8.762	-0.051
	MnOH+	1.508e-10	1.339e-10	-9.822	-9.873	-0.051
	MnCl2	2.804e-13	2.813e-13	-12.552	-12.551	0.001
	MnCl3-	3.250e-17	2.887e-17	-16.488	-16.540	-0.051
	Mn(OH)3-	1.343e-20	1.193e-20	-19.872	-19.924	-0.051
Mn(3)	6.582e-30					
	Mn+3	6.582e-30	2.267e-30	-29.182	-29.645	-0.463
Mn(6)	0.000e+00					
	MnO4-2	0.000e+00	0.000e+00	-62.333	-62.539	-0.206
Mn(7)	0.000e+00					
	MnO4-	0.000e+00	0.000e+00	-70.078	-70.130	-0.051
Na	1 340e-03					
	Na+	1.337e-03	1 189e-03	-2.874	-2.925	-0 051
	NaHCO3	2.736e-06	2.745e-06	-5 563	-5.561	0.001
	NaSO4-	1.078e-06	9.576e-07	-5.967	-6.019	-0.051
	NaCO3-	2.363e-08	2.099e-08	-7.627	-7.678	-0.051
O(0)	0.000e+00					
	O2	0.000e+00	0.000e+00	-51.701	-51.699	0.001
S(6)	3.718e-04					
	SO4-2	2.686e-04	1.689e-04	-3.571	-3.772	-0.201
	CaSO4	7.633e-05	7.658e-05	-4.117	-4.116	0.001
	MgSO4	2.552e-05	2.560e-05	-4.593	-4.592	0.001
	NaSO4-	1.078e-06	9.576e-07	-5.967	-6.019	-0.051
	KSO4-	3.190e-07	2.834e-07	-6 496	-6.548	-0.051
	MnSO4	2.935e-08	2.945e-08	-7.532	-7.531	0.001
	HSO4-	1.804e-09	1.603e-09	-8.744	-8.795	-0.051
	FeSO4	4.355e-10	4.370e-10	-9.361	-9.360	0.001
	CaHSO4+	5.306e-11	4.714e-11	-10.275	-10.327	-0.051
	UO2SO4	6.457e-12	6.479e-12	-11.190	-11.189	0.001
	UO2(SO4)2-2	1.456e-14	9.064e-15	-13.837	-14.043	-0.206
	FeHSO4+	3.646e-16	3.239e-16	-15.438	-15.490	-0.051
	FeSO4+	3.720e-19	3.305e-19	-18.429	-18.481	-0.051
	Fe(SO4)2-	1.333e-21	1.184e-21	-20.875	-20.927	-0.051
	FeHSO4+2	1.652e-25	1.029e-25	-24.782	-24.988	-0.206
	USO4+2	6.775e-31	4.218e-31	-30.169	-30.375	-0.206
	U(SO4)2	4.537e-31	4.552e-31	-30.343	-30.342	0.001

Si	2.115e-04					
	H4SiO4	2.113e-04	2.119e-04	-3.675	-3.674	0.001
	H3SiO4-	2.312e-07	2.054e-07	-6.636	-6.687	-0.051
	H2SiO4-2	1.156e-13	7.197e-14	-12.937	-13.143	-0.206
U(3)	0.000e+00					
	U+3	0.000e+00	0.000e+00	-44.263	-44.726	-0.463
U(4)	4.301e-15					
	U(OH)4	4.299e-15	4.313e-15	-14.367	-14.365	0.001
	U(OH)3+	2.241e-18	1.991e-18	-17.650	-17.701	-0.051
	U(OH)2+2	2.115e-22	1.317e-22	-21.675	-21.880	-0.206
	U(CO3)4-4	1.504e-23	2.261e-24	-22.823	-23.646	-0.823
	UOH+3	3.157e-27	1.087e-27	-26.501	-26.964	-0.463
	U(CO3)5-6	1.168e-27	1.643e-29	-26.933	-28.784	-1.852
	USO4+2	6.775e-31	4.218e-31	-30.169	-30.375	-0.206
	U(SO4)2	4.537e-31	4.552e-31	-30.343	-30.342	0.001
	U+4	4.757e-33	7.150e-34	-32.323	-33.146	-0.823
	UCl+3	4.974e-35	1.713e-35	-34.303	-34.766	-0.463
	U6(OH)15+9	0.000e+00	0.000e+00	-107.809	-111.976	-4.167
U(5)	6.617e-12					
	UO2+	6.617e-12	5.878e-12	-11.179	-11.231	-0.051
	UO2(CO3)3-5	7.421e-21	3.841e-22	-20.130	-21.416	-1.286
U(6)	1.303e-05					
	UO2(CO3)2-2	8.809e-06	5.485e-06	-5.055	-5.261	-0.206
	UO2(CO3)3-4	4.032e-06	6.060e-07	-5.394	-6.218	-0.823
	UO2CO3	1.907e-07	1.913e-07	-6.720	-6.718	0.001
	UO2(OH)3-	1.571e-09	1.396e-09	-8.804	-8.855	-0.051
	UO2OH+	1.266e-09	1.124e-09	-8.898	-8.949	-0.051
	UO2+2	5.381e-11	3.350e-11	-10.269	-10.475	-0.206
	(UO2)3(CO3)6-6	2.123e-11	2.987e-13	-10.673	-12.525	-1.852
	UO2SO4	6.457e-12	6.479e-12	-11.190	-11.189	0.001
	(UO2)2(OH)2+2	2.074e-13	1.292e-13	-12.683	-12.889	-0.206
	(UO2)3(OH)5+	1.945e-13	1.728e-13	-12.711	-12.763	-0.051
	UO2Cl+	1.909e-14	1.696e-14	-13.719	-13.771	-0.051
	(UO2)3(OH)7-	1.607e-14	1.427e-14	-13.794	-13.845	-0.051
	UO2(SO4)2-2	1.456e-14	9.064e-15	-13.837	-14.043	-0.206
	(UO2)4(OH)7+	6.777e-16	6.020e-16	-15.169	-15.220	-0.051
	(UO2)3(OH)4+2	4.371e-16	2.722e-16	-15.359	-15.565	-0.206
	UO2(OH)4-2	3.093e-16	1.926e-16	-15.510	-15.715	-0.206
	(UO2)2OH+3	5.662e-17	1.950e-17	-16.247	-16.710	-0.463
	UO2Cl2	3.134e-19	3.144e-19	-18.504	-18.502	0.001

------------------------Saturation indices------------------------

Phase	SI	log IAP	log KT	
Anhydrite	-2.05	-6.38	-4.34	CaSO4
Aragonite	-0.17	-8.46	-8.29	CaCO3
Artinite	-8.33	1.83	10.16	MgCO3:Mg(OH)2:3H2O
B-UO2(OH)2	-2.41	3.40	5.81	UO2(OH)2
Birnessite	-17.16	26.44	43.60	MnO2
Bixbyite	-17.33	34.37	51.71	Mn2O3
Brucite	-6.59	10.78	17.37	Mg(OH)2

Calcite	-0.02	-8.46	-8.44	CaCO3
Chalcedony	-0.03	-3.67	-3.64	SiO2
Chrysotile	-8.19	24.99	33.18	Mg3Si2O5(OH)4
Clinoenstatite	-4.63	7.11	11.73	MgSiO3
CO2(g)	-1.55	-19.73	-18.18	CO2
Coffinite	-1.61	-18.77	-17.15	USiO4
Cristobalite	0.02	-3.67	-3.69	SiO2
Diopside	-5.82	14.70	20.52	CaMgSi2O6
Dolomite	-0.51	-17.41	-16.91	CaMg(CO3)2
Dolomite(d)	-1.09	-17.41	-16.32	CaMg(CO3)2
Epsomite	-4.68	-6.87	-2.19	MgSO4:7H2O
Fe(OH)2.7Cl.3	2.08	12.24	10.17	Fe(OH)2.7Cl0.3
Fe(OH)3(a)	-2.74	15.36	18.10	Fe(OH)3
Fe3(OH)8	-9.82	36.82	46.64	Fe3(OH)8
Forsterite	-11.37	17.88	29.25	Mg2SiO4
Goethite	2.87	15.36	12.49	FeOOH
Greenalite	-9.84	10.97	20.81	Fe3Si2O5(OH)4
Gummite	-7.45	3.40	10.85	UO3
Gypsum	-1.80	-6.38	-4.58	CaSO4:2H2O
H2(g)	-18.50	-18.50	0.00	H2
H2O(g)	-1.71	-0.00	1.71	H2O
Halite	-7.92	-6.35	1.56	NaCl
Hausmannite	-20.68	42.31	62.99	Mn3O4
Hematite	7.70	30.71	23.01	Fe2O3
Huntite	-5.85	-35.31	-29.47	CaMg3(CO3)4
Hydromagnesite	-17.28	-25.03	-7.75	Mg5(CO3)4(OH)2:4H2O
Jarosite(ss)	-16.31	13.48	29.79	(K0.77Na0.03H0.2)Fe3(SO4)2(OH)6
Jarosite-K	-16.88	14.14	31.02	KFe3(SO4)2(OH)6
Jarosite-Na	-20.27	14.78	35.05	NaFe3(SO4)2(OH)6
JarositeH	-24.54	10.76	35.31	(H3O)Fe3(SO4)2(OH)6
Magadiite	-7.40	-21.70	-14.30	NaSi7O13(OH)3:3H2O
Maghemite	-2.09	30.71	32.80	Fe2O3
Magnesite	-1.04	-8.95	-7.91	MgCO3
Magnetite	5.68	36.82	31.13	Fe3O4
Manganite	-8.15	17.19	25.34	MnOOH
Melanterite	-9.24	-11.55	-2.31	FeSO4:7H2O
Mirabilite	-8.14	-9.62	-1.48	Na2SO4:10H2O
Mn2(SO4)3	-65.65	-18.58	47.07	Mn2(SO4)3
MnCl2:4H2O	-15.17	-12.80	2.37	MnCl2:4H2O
MnSO4	-12.69	-9.72	2.97	MnSO4
Na4UO2(CO3)3	-23.43	-39.72	-16.29	Na4UO2(CO3)3
Nahcolite	-4.69	-15.71	-11.02	NaHCO3
Natron	-10.08	-11.70	-1.62	Na2CO3:10H2O
Nesquehonite	-3.44	-8.95	-5.51	MgCO3:3H2O
Nsutite	-16.13	26.44	42.56	MnO2
O2(g)	-48.78	37.00	85.78	O2
Portlandite	-12.13	11.27	23.40	Ca(OH)2
Pyrochroite	-7.26	7.94	15 20	Mn(OH)2
Pyrolusite	-16.21	26.44	42.65	MnO2
Quartz	0.42	-3.67	-4.10	SiO2
Rhodochrosite	-0.69	-11.79	-11 10	MnCO3
Rhodochrosite(d)	-1.40	-11.79	-10.39	MnCO3

Rutherfordine	-1.90	-16.32	-14.42	UO2CO3
Schoepite	-2.23	3.40	5.64	UO2(OH)2:H2O
Sepiolite	-5.43	10.54	15.97	Mg2Si3O7.5OH:3H2O
Sepiolite(d)	-8.12	10.54	18.66	Mg2Si3O7.5OH:3H2O
Siderite	-2.78	-13.62	-10.84	FeCO3
Siderite(d)(3)	-3.17	-13.62	-10.45	FeCO3
Silicagel	-0.57	-3.67	-3.10	SiO2
SiO2(a)	-0.90	-3.67	-2.78	SiO2
Talc	-4.66	17.64	22.30	Mg3Si4O10(OH)2
Thenardite	-9.45	-9.62	-0.17	Na2SO4
Thermonatrite	-11.88	-11.70	0.18	Na2CO3:H2O
Tremolite	-11.41	47.04	58.46	Ca2Mg5Si8O22(OH)2
Trona	-16.57	-27.41	-10.85	NaHCO3:Na2CO3:2H2O
U(OH)2SO4	-19.84	-32.75	-12.91	U(OH)2SO4
U3O8(c)	-1.94	-8.28	-6.34	U3O8
U4O9(c)	-1.63	-41.88	-40.25	U4O9
UO2(a)	-5.49	-15.09	-9.61	UO2
UO3(gamma)	-4.69	3.40	8.09	UO3
Uraninite(c)	-0.95	-15.09	-14.15	UO2
Uranophane	-6.76	10.73	17.49	Ca(UO2)2(SiO3OH)2

End of simulation.

Reading input data for simulation 2.

End of run.
